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Front Cover: A puff adder *Bitis arietans* photographed in Kenya, by Bobby Bok. There is an article about this species on p. 18.

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RESEARCH ARTICLE

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Potential impacts of refugee camps on wetland herpetofauna in Uganda

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ABSTRACT – Wetlands are one of the world's fastest shrinking ecosystems, yet they are home to roughly 43% of all reptile and amphibian species. Sub-Saharan Africa has the fastest growing human population on the planet while also experiencing significant internal migrations of displaced peoples who settle in refugee camps. These camps are often in remote and previously undisturbed areas where interactions with wildlife are common. Reptiles and amphibians can be used to assess the health and resilience of habitats as a result of their sensitivity to environmental conditions. We sampled the herpetofauna of five wetlands located around two major refugee camps in Uganda using time-constrained visual encounter surveys during both nighttime and daytime. We provide baseline data on these wetland populations and compared them using alpha and beta diversity indices. These are the first data for refugee camp herpetofaunal communities, allowing for future comparisons of the effects of increased human pressure within these camps as well as the ability to better incorporate education and management to help conserve these wetlands and the species that inhabit them.

INTRODUCTION

Wetlands have been disappearing at alarming rates and their ecosystem services, including regulation of both local and global climate, biodiversity protection, maintenance of local hydrology, water filtration and many more are being degraded or lost (Costanza et al., 2014). These critical ecosystems contend with many anthropogenic threats such as damming, canalisation, deteriorating water quality due to various pollutants, and ever-increasing development and urbanisation (Davidson, 2014). Though wetlands play a vital role for many species, including humans, they are fragile ecosystems that must be managed and protected to sustainably harvest the many benefits they provide. It is estimated that over 55% of the world's natural wetlands have been lost, increasing the importance of safeguarding what remains (Davidson, 2014; Dixon et al., 2016). One of the most important environmental benefits that wetlands provide is habitat for a great diversity of fauna and flora, including roughly 43% of all herpetofauna species (Hails, 1997; Villamarin et al., 2022).

Reptiles and amphibians use both the aquatic and terrestrial environments and are important indicators of local ecosystem health (Wilson & McCranie, 2003; Mifsud, 2014; Paudel et al., 2022). Many species are sensitive to changes in their environment, allowing researchers to examine the effects of habitat alterations or human activities based on the response of the local herpetofauna. Unfortunately, due to many of the above-mentioned threats affecting wetlands, these groups of organisms are also declining around the world, with roughly 41% of amphibians and 21% of reptiles classified as threatened by the IUCN Red List (Cox et al., 2022; IUCN, 2023). Given their roles in the environment, their status as indicator species of habitat health, and their global plight, reptiles and amphibians warrant increased research and conservation action.

Africa is home to 2,123 reptile and 1,189 amphibian species, with new species being discovered constantly (IUCN, 2023), but also has the most rapidly expanding human population on the planet and, consequently, high rates of human displacement and habitat conversion (Adepoju, 2000; Crisp, 2000; Burgess et al., 2007; Brandt et al., 2017; Kaba, 2020). These displacements and internal migrations have created sites of high human density, often in remote and previously wild areas. To find safe, permanent settling grounds, millions of people have fled and continue to flee conflicts, bringing people and wildlife and their habitats into closer and closer association. Uganda, a relatively small nation in central Africa, has the greatest biodiversity per unit area in Africa (Eilu & Winterbottom, 2006; Plumptre et al., 2018). It is also the country with the greatest number of endemic vertebrates on mainland Africa (Plumptre et al., 2007). At the same time, twelve officially recognised refugee settlements, with over 1.5 million refugees (as of

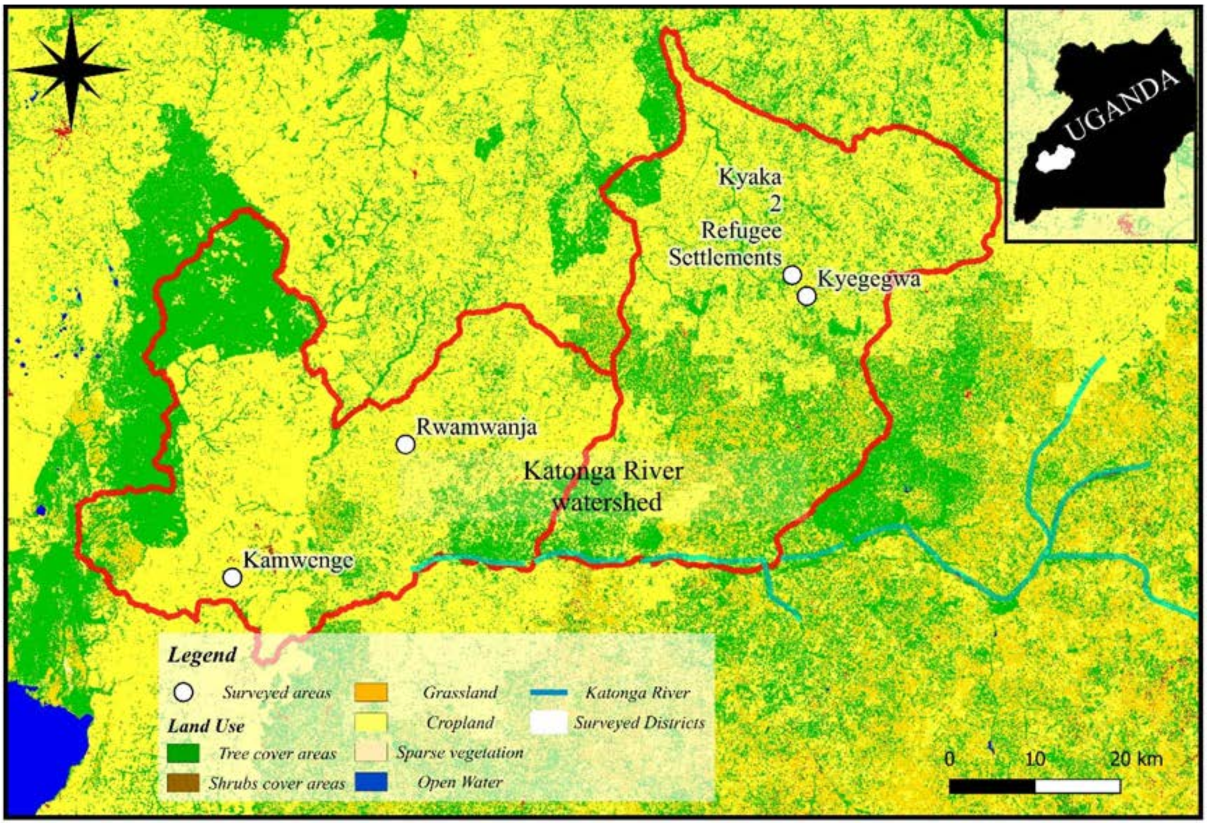

Figure 1. The study area in Uganda showing the locations of the refugee camps and surrounding land cover

30 September 2023, https://data.unhcr.org/en/country/uga), are located in Uganda, many of which have greatly expanded of late due to the political instability and civil wars in Sudan and South Sudan. As refugee numbers increase, local ecosystems must cope with added pressure and use, with clear evidence of increased disturbance closer to refugee camp centres. To begin the process of restoring wetlands located around refugee settlements, our team sampled the herpetofaunal communities of five wetlands within 15 km of two major refugee camps in Uganda. By identifying the species using these habitats, we can make inferences on the status of the wetlands as well as make informed decisions on how to improve them. Herein, we present the first data on herpetofaunal communities associated with refugee camp wetlands and suggest possible improvements for these vital and dwindling ecosystems.

MATERIALS & METHODS

Site Description

We sampled five wetlands in the districts of Kamwenge and Kyegegwa, Uganda, around the Rwamwanja and Kyaka 2 refugee settlements (Fig. 1). Rwamwanja, established in 1964 to host Rwandan refugees, is located in Kamwenge district in south-western Uganda and is home to roughly 70,000 refugees. Kyaka 2, located in Kyegegwa district, has nearly quadrupled in size since 2017 and now houses around 121,000 refugees (https://data.unhcr.org/en/country/uga). Around Rwamwanja we sampled two wetlands, Rushango wetland (RusKam) in Kabingo parish, Bihanga subcounty and Kajororo wetland (RwaKam), the primary water source for the settlement, in Nkoma-Katayelba subcounty just at the border of Rwamwanja settlement. Around Kyaka 2, we sampled Komuchwezi wetland (KomKye), Kyakatwanga wetland (KyaKye) and Sweeswe wetland (SweKye), all of which are associated with the Katonga river watershed. Most of the water used by Kyaka 2 is drawn from Sweeswe wetland. All wetlands were within 15 km of the refugee camps and were known to be used by people living in the camps. The refugee settlements are located along well organised road networks, forming areas that look like small towns or Rural Growth Centres (RCGs), built using mud or bricks, with iron sheet roofs. Refugees and their families are usually given between ¼ of an acre to an acre for subsistence farming and for building a home, with each parcel separated by a hedge or fence. The refugees tend to have better sanitation systems than the surrounding local communities, with more reliable access to freshwater, which can often create resentment amongst local communities. Due to the burgeoning numbers of refugees, many will venture outside their homesteads to acquire firewood and building materials, impacting the local environment. Refugees often also compete with locals for jobs, given their willingness to work for lower pay rates, causing animosity between locals and refugees and also increasing the use of natural resources from the surrounding environment by locals.

Sampling

From 13–25 October 2021, there were herpetological surveys in the five wetlands, undertaken by three-person field teams each day. Overall, each team member spent 90 hours in the field for a total of 270 man-hours. Predominantly for amphibian fauna, we surveyed the study areas from 18:00–21:00 h, as this is when most amphibians are active. To improve our chances of catching diurnal species, especially reptiles emerging to bask, we also surveyed the study area in the mornings (06:00–09:30 h). For the Visual Encounter Surveys (VES), each field researcher was positioned 5 metres apart and walked designated 500 m paths around the wetlands (Heyer et al., 1994; Freeman et al., 2003). Transects were variable depending on the length of wetland features at each site, but each transect at each site was separated by a minimum distance of 500 m. This included examining all possible refugia such as, turning over rocks and fallen logs, peeling tree bark, digging through leaf litter, and searching through trees, rotten tree stumps, tree buttresses, inside termite mounds and burrows. All refugia were replaced after inspection. Additionally, we used dip-netting to document any aquatic species, including tadpoles. We released all captured specimens unharmed apart from those that were not identifiable in the field, which we preserved in alcohol for later identification. We also opportunistically examined locally used Papyrus funnel traps (traditionally used for catching mudfish) when we encountered them at the field sites; these traps often caught certain frog species (e.g. *Xenopus*, Behangana et al., 2023). We also incorporated all opportunistic encounters into our dataset. Though we attempted to use pitfall traps to supplement our sampling effort, this method unfortunately failed due to vandalism.

We identified all captured individuals by referencing Schiøtz (1999), Spawls et al. (2002; 2006), Channing & Howell (2006), AmphibiaWeb (2021), the Reptile Database (Uetz et al., 2021) and Frost (2021).

Table 1. Anuran species and counts at five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Taxa	KomKye	KyaKye	SweKye	RwaKam	RusKam	Total
Hyperoliidae						
Afrixalus fulvovittatus	11	1	8	4	2	26
Hyperolius balfouri			1			1
Hyperolius cinnamomeoventris	5	3	4	3	3	18
Hyperolius kivuensis	9	1	2	5	6	23
Hyperolius viridiflavus	2	2	2	5	2	13
Kassina senegalensis	9	2		1		12
Pyxicephalidae						
Amietia nutti		2		1		3
Arthroleptidae						
Arthroleptis cf. poecilonotus			1			1
Leptopelis bocagii		1	1	2	1	5
Dicroglossidae						
Hoplobatrachus occipitalis				1		1
Phrynobatrachidae						
Phrynobatrachus cf. acridoides	5	12	3		2	22
Phrynobatrachus cf. bullans					1	1
Phrynobatrachus cf. parvulus	1					1
Phrynobatrachus mababiensis	8	2			2	12
Phrynobatrachus natalensis	15	10	5	2	1	33
Ptychadenidae						
Ptychadena cf. schillukorum		1				1
Ptychadena cf.bibroni		2				2
Ptychadena nilotica	27	25	11	8	7	78
Ptychadena oxyrhynchus	1					1
Ptychadena porosissima	2	3	1	1	2	9
Bufonidae						
Sclerophrys maculata	1	1		1	2	5
Sclerophrys pusilla					1	1
Sclerophrys regularis	5	5	2	5	3	20
Pipidae						
Xenopus cf. fischbergi			1			1
Xenopus victorianus	1		1	5		7
Total	**102**	**73**	**43**	**44**	**35**	**297**

Table 2. Reptile species and counts at five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Taxa	KomKye	KyaKye	SweKye	RwaKam	RusKam	Total
Serpentes						
Bitis arietans			1		1	2
Dendroaspis jamesoni			1		1	2
Hapsidophrys smaragdina			1		1	2
Philothamnus battersbyi			1		1	2
Psammophis mossambicus	2		1	1	2	6
Python sebae			1		1	2
Naja subflava	4		2	1	2	9
Sauria						
Acanthocercus ugandaensis	3			3		6
Chamaeleo gracilis	1	1			1	3
Hemidactylus mabouia					1	1
Trachylepis maculilabris		2	1	2	1	6
Trachylepis striata	4	2	1	2	1	10
Trioceros ellioti				1	1	2
Varanus niloticus				1	1	2
Chelonia						
Pelomedusa neumanni	1			1	1	3
Total	**15**	**5**	**10**	**12**	**16**	**58**

To compare the diversity and evenness of herpetofauna between refugee settlements and to allow comparisons with previously published results from the country, we calculated the following indices: the relative abundance of each species at each wetland, the Shannon-Weiner Index (H), the Simpson Diversity Index (λ), Margalef's Index (D) and Pielou's Evenness Index (E).

RESULTS

We recorded a total of 355 individuals (297 amphibians all of which were anurans and 58 reptiles) representing 18 families (8 amphibian, 10 reptile), 25 genera (11 amphibian, 14 reptile) and 40 species (25 amphibian, 15 reptile; Tables 1 & 2). Eight anurans and only one reptile (*Trachylepis striata*) were present at all five sampling sites. *Ptychadena nilotica* was the most common anuran species encountered, representing both the most abundant species at each sampling site and in the study (n = 78). With the exception of SweKye, Kyegegwa District wetlands had higher abundances of amphibians than the two wetlands in Kamwenge District. Only two species of amphibians constituted more than 10% of all individuals encountered amongst all five sites (*P. nilotica* and *Phrynobatrachus natalensis*). Interestingly, however, eight amphibian species were represented by a single individual, with each sampling site providing at least one of these singleton species records. For amphibians, both Shannon index and Margalef's index (Table 3) did not differ significantly between sites (in both cases P > 0.05 using ANOSIM). However, RwaKam and RusKam both had significantly higher evenness values (P < 0.05 using ANOSIM) than all other sites. Only one reptile (*Hemidactylus mabouia*) had a single record in the study, although 10 species were only represented by single individuals at each of the sites where they were encountered (but each was documented at more than one site). Five of the 15 reptile species observed in this study (Table 3; *T. striata*, *Trachylepis maculilabris*, *Psammophis mossambicus*, *Naja subflava*, *Acanthocercus ugandaensis*) amounted to 64% of all individuals found, with each of the five species representing more than 10% of the individuals found in the study. Statistical comparisons of univariate indices between sites could not be done due to small sample sizes for reptiles.

Table 3. Anuran and reptile diversity and evenness indices for five wetlands around two refugee camps in Kamwenge and Kyegegwa Districts, Uganda

Site	# of species	Shannon Index	Simpson Index	Margalef Index	Evenness
			Anurans		
All sites combined	25	2.53	0.88	4.22	0.79
KomKye	15	2.28	0.87	3.03	0.84
KyaKye	16	2.17	0.82	3.50	0.78
SweKye	14	2.27	0.86	3.46	0.86
RwaKam	14	2.41	0.90	3.44	0.91
RusKam	14	2.43	0.89	3.66	0.92
			Reptiles		
All sites combined	15	2.49	0.90	3.45	0.92
KomKye	6	1.66	0.79	1.85	0.92
KyaKye	3	1.06	0.64	1.24	0.96
SweKye	9	2.16	0.88	3.47	0.98
RwaKam	8	1.98	0.85	2.82	0.95
RusKam	14	2.60	0.92	4.69	0.99

DISCUSSION

Even with limited sampling over a period of just two weeks in the rainy season, we documented roughly 15% of Uganda's 262 reptile and amphibian species, of which 84 are amphibians and 178 reptiles (IUCN, 2023) although other authors provide slightly differing counts: 85 amphibians (Frost et al., 2022), 174 reptiles (Uetz et al., 2022). While all five sites harboured roughly equal numbers of amphibian species, Kyakatwanga and Komuchwezi wetlands had the fewest reptile species. Komuchwezi wetland is the most degraded of the sampled wetlands with heavy disturbance due to brick making and sand mining activities. Not only do these activities degrade the habitat, but they also increase human presence which may have reduced the presence of reptiles. Kyakatwanga wetland, though less disturbed than Komuchwezi, is nevertheless frequented by locals who access banana and rice plantations along its edges, likely resulting in human-reptile encounters. This assumption, that these interactions have reduced the abundance and presence of certain reptile species, is further supported by the absence of large, sedentary and easily-hunted reptiles found at almost all of the other sites (i.e. *Bitis arietans*, *Python sebae*) as well as the large, and often consumed, *Varanus niloticus*. Many previous studies have found lower diversity at more disturbed sites (Lieberman & Dock, 1982; Lieberman, 1986; Lenart et al., 1997; Glor et al., 2001).

Amongst amphibians, the most common species in the study seemed to also be the most common at each of the sampled sites, resulting in highly similar communities that differed only slightly due to singleton or low-abundance species being present at certain sites. This could possibly be a result of under sampling, as the low abundances of these species may have precluded their detection at sites where they were not encountered. Certainly, our short sampling period did not allow for perfect detection of all species present. However, if in fact the presence of some of the low-abundance or singleton species documented in this study is a true indication of their status at a site, it would be interesting to investigate the micro-conditions at each location that may be allowing these species to survive at one site rather than another. Ultimately, the consistency we saw among sites in the number of amphibian species does suggest that even highly-disturbed, and anthropogenically-impacted wetlands still act as refugia for a number of anuran species. The presence of singleton species also suggests that with habitat improvement and local support and education, these wetlands could provide refuge for more seldom-seen species. Most amphibians recorded in the study areas are typical wetland species, many of which are tolerant of anthropogenic changes to their habitats, with some even increasing in abundance in association with human disturbance, e.g. *Afrixalus fulvovittatus*, *Hyperolius kivuensis*, *Hyperolius viridiflavus*, *Kassina senegalensis*, *Phrynobatrachus mababiensis*, *Phrynobatrachus natalensis*, *Ptychadena nilotica* and *Sclerophrys regularis*. However, few reptilian species are tolerant of human disturbance and the species recorded are typical of the indigenous natural vegetation (Langdale-Brown, 1964).

This is the first study to sample multiple wetlands close to refugee camps in an effort to list the amphibian and reptile communities in these areas with a view to improve their status in the future. We found that although wetlands in refugee areas are often heavily degraded and play an important role in the acquisition of resources for locals, they still provide habitat to many species of herpetofauna. With this knowledge, we can begin to transform how these wetlands are used to better ensure the continued presence of species living alongside the extractive activities that will surely continue to expand. Activities such as subsistence farming, water extraction, channelisation, hunting and mining are constant pressures on the wildlife in these dwindling ecosystems, but with increased education and support, the impacts of these activities can be reduced. The timing and extent of these pressures on refugee area wetlands must be managed if the more sensitive species are to survive, and if habitat improvements are added to this management, then intact and healthy herpetofaunal communities can surely coexist on refugee area lands.

The refugee crisis, in fact, is contributing to the extinction of Africa's rarest turtle species *Cyclanorbis elegans* in Uganda and South Sudan (Luiselli et al., 2024; Walde et al., 2024), and therefore it is clear that the initiation of conservation projects directly targeting refugees and their activities will be of priority importance in the years to come.

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REFERENCES

Adepoju, A. (2000). Issues and recent trends in international migration in Sub-Saharan Africa. *International Social Science Journal* 52: 383–394.

AmphibiaWeb (2021). University of California, Berkeley, CA, USA. https://amphibiaweb.org.

Behangana, M., Byaruhanga, A., Magala, R., Katumba, R., Kagurusi, A., Dendi, D. & Luiselli, L. (2023). An analysis of the herpetofauna communities in the last moderately altered, high-altitude wetlands of Uganda. *Wetlands* 43: 88.

Brandt, M., Rasmussen, K., Peñuelas, J., Tian, F., Schurgers, G., Verger, A., Mertz, O., Palmer, J.R. & Fensholt, R. (2017). Human population growth offsets climate-driven increase in woody vegetation in sub-Saharan Africa. *Nature Ecology and Evolution* 1: 81.

Burgess, N.D., Balmford, A., Cordeiro, N.J., Fjeldså, J., Kueper, W., Rahbek, C., Sanderson, E.W., Scharlemann, J.P., Sommer, J.H. & Williams, P.H. (2007). Correlations among species distributions, human density and human infrastructure across the high biodiversity tropical mountains of Africa. *Biological Conservation* 134: 164–177.

Channing, A. & Howell, K.M. (2006). Amphibians of East Africa. Edition Chimaira, Frankfurt am Main. 432 p.

Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. & Turner, R.K. (2014). Changes in the global value of ecosystem services. *Global environmental change* 26: 152–158.

Cox, N., Young, B.E., Bowles, P., Fernandez, M., Marin, J., Rapacciuolo, G., ... & Xie, Y. (2022). A global reptile assessment highlights shared conservation needs of tetrapods. *Nature* 605: 285–290.

Crisp, J. (2000). Africa's refugees: patterns, problems and policy challenges. *African Yearbook of International Law Online* 8: 93–118.

Davidson, N.C. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. *Marine and Freshwater Research* 65: 934–941.

Dixon, M.J.R., Loh, J., Davidson, N.C., Beltrame, C., Freeman, R. & Walpole, M. (2016). Tracking global change in ecosystem area: The Wetland Extent Trends index. *Biological Conservation* 193: 27–35.

Eilu, G. & Winterbottom, B. (2006). Uganda biodiversity and tropical forest assessment: Final report. USAID Epiq II task order no. 351. Available Online: https://studylib.net/doc/8889611/uganda-biodiversity-and-tropical-forest-assessment-report.

Freeman, N.S., Pomeroy, D.E. & Tushabe, H. (2003). On the use of timed species counts to estimate abundance in species-rich communities. *African Journal of Ecology* 41: 337–348.

Frost, D.R. (2021). Amphibian Species of the World: an online reference. Version 6.1. Electronic Database accessible at https://amphibiansoftheworld.amnh.org/index.php. Accessed on 30 Sep 2021. American Museum of Natural History, New York. https://doi.org/10.5531/db.vz.0001

Glor, R.E., Flecker, A.S., Benard, M.F. & Power, A.G. (2001). Lizard diversity and agricultural disturbance in a Caribbean forest landscape. *Biodiversity & Conservation* 10: 711–723.

Hails, A.J. (Ed.) (1997). Wetlands, Biodiversity and the Ramsar Convention: The Role of the Convention on Wetlands in the Conservation and Wise Use of Biodiversity. Ramsar Convention Bureau, Gland, Switzerland. https://www.ramsar.org/sites/default/files/documents/library/wetlands_biodiversity_and_the_ramsar_convention.pdf.

Heyer, W.R., Donnely, M.A., McDiarmid, R.W., Hayek, L.C. & Foster, M.S. (Eds.) (1994). Measuring and monitoring biological diversity: standard methods for reptiles and amphibians. Smithsonian Institution Press, Washington. 384 pp.

International Union for Conservation of Nature (IUCN) (2023). The IUCN Red list of threatened species. Version 2023-1. https://www.iucnredlist.org. Downloaded on 29 July 2023.

Kaba, A.J. (2020). Explaining Africa's rapid population growth, 1950 to 2020: Trends, factors, implications, and recommendations. *Sociology Mind* 10: 226–268.

Langdale-Brown, I., Osmaston, H.A. & Wilson, J.G. (1964). The vegetation of Uganda and its bearing on land-use. Kampala, Uganda's Government Press.

Lenart, L.A., Powell, R., Parmerlee Jr, J.S., Lathrop, A. & Smith, D.D. (1997). Anoline diversity in three differentially altered habitats in the Sierra de Baoruco, República Dominicana, Hispaniola 1. *Biotropica* 29: 117–123.

Lieberman, S. & Dock, C.F. (1982). Analysis of the leaf litter arthropod fauna of a lowland tropical evergreen forest site (La Selva, Costa Rica). *Revista de Biologia Tropical* 30: 27–34.

Lieberman, S.S. (1986). Ecology of the leaf litter herpetofauna of a Neotropical rain forest: La Selva, Costa Rica. *Acta Zoologica Mexicana* 15: 1–72.

Luiselli, L., Demaya, G.S., Benansio, J.S., Ajong, S.N., Behangana, M., Marsili, L., Gio-vacchini, P., Dendi, D., Fa, J.E., Walde, A.D. & Battisti, C. (2024). Searching priorities for a species at the brink of extinction: Threats analysis on the critically endangered Nubian Flapshell Turtle (*Cyclanorbis elegans*). *African Journal of Ecology* 62, e13256. https://doi.org/10.1111/aje.13256.

Mifsud, D.A. (2014). A status assessment and review of the herpetofauna within the Saginaw Bay of Lake Huron. *Journal of Great Lakes Research* 40: 183–191.

Paudel, J., Khanal, L., Pandey, N., Upadhyaya, L.P., Sunar, C.B., Thapa, B., Bhatta, C.R, Pant, R.R. & Kyes, R.C. (2022). Determinants of herpetofaunal diversity in a threatened wetland ecosystem: A case study of the Ramaroshan Wetland Complex, Western Nepal. *Animals* 13: 135.

Plumptre, A.J., Davenport, T.R.B., Behangana, M., Kityo, R., Eilu, G., Ssegawa, P. et al. (2007). The biodiversity of the Albertine Rift. *Biological Conservation* 134: 178–194.

Schiøtz, A. (1999). Treefrogs of Africa. Edition Chimaira, Frankfurt am Main. 350 pp.

Spawls, S., Howell, K. & Drewes, C. (2006). Pocket Guide to the Reptiles and Amphibians of East Africa. A & C Black Publishers, London. 240 pp.

Spawls, S., Howels, K., Drewes, C. & Ashe, J. (2002). A Field Guide to the Reptiles of East Africa. A & C Black Publishers, London and San Diego. 543 pp.

Tumusiime, D.M., Turyahabwe, N., Kakuru, W. & Barasa, B. (2018). Wetland use/cover changes and local perceptions in Uganda. Kampala, Makerere University Press.

Uetz, P., Freed, P., Aguilar, R., Hošek, J. (Eds.) (2021). The Reptile Database. http://www.reptile-database.org. Accessed on 29 June 2023.

Villamarín, F., Moraes, L.J., Ferrara, C.R., Kaefer, I.L., Werneck, F.P. & de Fraga, R. (2022). Ecology and Conservation of Wetland Amphibians and Reptiles. In *Encyclopedia of Inland Waters*, 2nd ed., Volume 3. 256–266 pp. Mehner, T. & Tockner, K. (Eds.). Elsevier: Amsterdam, The Netherlands.

Walde, A.D., Demaya, G.S., Behangana, M., Luiselli, L. (2024). Refugee crisis also affects biodiversity. *Nature (London)* 630 (8017), 563.

WCS (2016) Nationally Threatened Species for Uganda. National Red List for Uganda for the following taxa: Mammals, Birds, Reptiles, Amphibians, Butterflies, Dragonflies and Vascular Plants. Prepared by WCS, the Government of Uganda, the Uganda Wildlife Authority. 70 pp.

Wilson, L.D. & McCranie, J.R. (2003). Herpetofaunal indicator species as measures of environmental stability in Honduras. *Caribbean Journal of Science* 39: 50–67.

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RESEARCH ARTICLE

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New distribution records, morphology and natural history notes of the endemic Colombian lizard *Anolis limon*

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ABSTRACT – *Anolis limon* is a species endemic to the inter-Andean valley of the Magdalena River, Colombia. We report three new localities for *A. limon* in the department of Tolima, Colombia, and provide data on its morphology, natural history and behaviour. Specimens were collected during field surveys of the eastern slope of the Central Cordillera in the Colombian Andes and their external features (scales) and internal characteristics (hemipenes) were compared with literature descriptions. We detected some variation in body size and meristic data between populations of *A. limon*. Furthermore, the distribution of *A. limon* was limited to the eastern slope of the Central Cordillera, located in the middle of the Magdalena region. This zone is highly fragmented and degraded, which may affect *A. limon* populations, as other animal species from these localities have disappeared in the last decade. Consequently, an evaluation of the conservation status of *A. limon* is needed.

INTRODUCTION

The genus *Anolis* (Daudin, 1892) has 440 species (Uetz et al., 2024) making it one of the most diverse groups of reptiles (Moreno-Arias & Calderón-Espinosa, 2016). In Colombia, the genus has 79 species (Uetz et al., 2024), nine of which have been registered in the Tolima department (Llano-Mejía et al., 2010), and six for the municipality of Falan, Tolima (Gallego et al., 2008).

Anolis limon is an endemic species from the inter-Andean valley of the Magdalena River of Colombia (Choco-Magdalena biogeographic province), reported in the departments of Antioquia and Caldas, between 520 and 1093 m a.s.l. (Velasco & Hurtado-Gómez, 2014; Rojas-Morales et al., 2019; Ramírez-Chaves et al., 2021). The external and internal morphology of this species was detailed in the original description by Velasco & Hurtado-Gómez (2014). However, to date there is no description of hemipenial morphology, which in squamate reptiles is an important systematic and taxonomic trait (Köhler et al., 2007; Klaczko et al., 2015).

Recently, the potential distribution of *A. limon*, with data on its habitat and threats, has been summarised by Moreno-Arias et al. (2021). Nevertheless, there is still a lack of knowledge about its natural history, morphological variation and ecology. Herein, we report three new localities for *A. limon* in the department of Tolima, Colombia, as well as expanding our understanding of morphological variation in the species including, for the first time, data on hemipenial morphology. We also provide some comments on its natural history, behaviour and current distribution.

MATERIALS AND METHODS

Field surveys were conducted in the municipalities of Falan and Armero (Department of Tolima), on the eastern slope of the Central Cordillera in the Colombian Andes. Falan area is characterised by its heterogeneous landscape between agricultural fields, mainly of *Annona muricata*, *Theobroma cacao*, *Persea americana*, and remnants of tropical humid forests (Agenda Ambiental del Municipio de Falan, 2011). The Armero zone appears to be a transition area between a tropical dry forest and humid forest.

The *A. limon* specimens were collected during two field trips, from 10 October to 16 November 2020 (Falan) and 21 June 2023 (Armero). The lizards were found during visual encounter surveys, between 18:00 h and 23:00 h, following common transit trails near water sources used by the locals covering different types of habitats and arboreal strata, where captures were made manually (Leal & Losos, 2000). The individuals collected were sacrificed with 2% roxicaine, fixed with a 10% formalin and stored in 70% alcohol (Angulo et al., 2006). The specimens were deposited in the zoological collection of the University of Tolima (CZUT) and the Natural History Museum of the University of Cauca (MHNUC). Collection permit was authorised by the Ministerio de Ambiente, Vivienda y Desarrollo Territorial (ANLA Resolutions 02191 of 2018).

For identification of the species, we followed the taxonomic keys and descriptions available in Batista et al. (2015), Velasco & Hurtado-Gómez (2014) and Williams (1988). The morphological character terminology used in this work is based on Köhler (2014). All specimens were

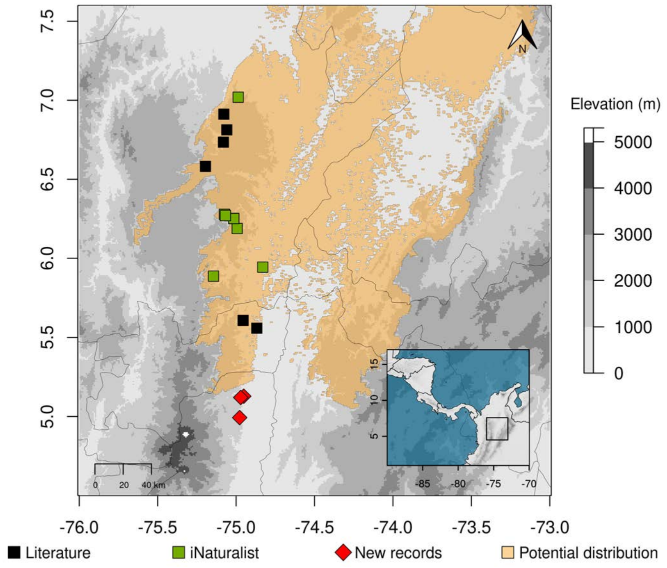

Figure 1. Distribution map of *Anolis limon* from literature, iNaturalist and new records. The potential distribution was obtained from BioModels of the Humboldt Institute (Moreno-Arias et al., 2019).

measured from the tip of the snout to the vent (SVL) with a digital calliper to the nearest 0.1 mm. For the distribution map, we compiled reports from published literature (Velasco & Hurtado-Gómez, 2014; Rojas-Morales et al., 2019; Ramírez-Chaves et al., 2021) and iNaturalist (https://www.inaturalist.org/. Accessed on 8 January 2024.). Only iNaturalist records in which the species was recognisable and had "Research Grade" were used. In Figure 1, we show the potential distribution of *A. limon*, this is based on a climatic-level distribution model sourced from the BioModelos dataset at the Humboldt Institute (Moreno-Arias et al., 2019) which corresponds precisely to the one proposed as a potential distribution for *A. limon* by Moreno-Arias et al. (2021).

Two hemipenes were also prepared. An inverted hemipene was everted following the procedures outlined by Zaher (1999), although to soften the tissue we used warm water instead of KOH. The second hemipene was prepared on a freshly sacrificed specimen, following the procedure proposed by Zaher & Prudente (2003). The hemipenes were treated with an alcoholic alizarin solution to contrast surface ornamentation and to reveal deep calcified structures (Harvey & Embert, 2008). Terminology for hemipenial morphology follows Köhler et al. (2007), Myers et al. (1993), Angiolella et al. (2016) and Savage (1997).

RESULTS

Three adult females, an adult male and a juvenile female were collected in the locality of Cúcuta (5.128479°, -74.951279°; 915 m a.s.l.), in a small gallery forest next to the river Murillo, Falan. Another adult male and three females were collected in the locality of Piedecuesta, around the Normal Superior school of Falan (5.120412°, -74.970604°; 1069 m a.s.l.), within a gallery forest. Additionally, another male was collected in the locality of La Parroquia, municipality of Armero (4.9929691°, -74.9772454°; 1076 m a.s.l.) in a gallery forest. All specimen collection sites are indicated in Figure 1.

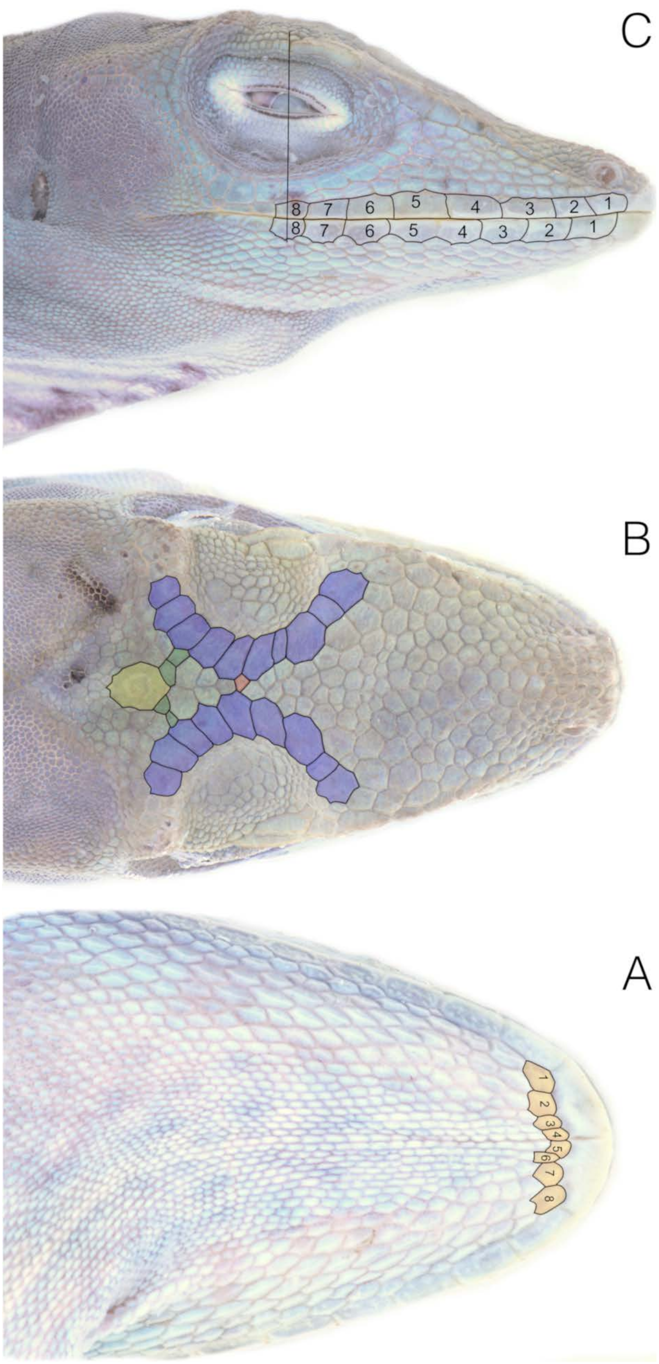

Figure 2. Scales of head of *Anolis limon* - **A.** Ventral view, postmental scales, **B.** Dorsal view, red = scales between supraorbital semicircles, blue = supraorbital semicircles, yellow = interparietal scale, and green = scales between interparietal scale and supraorbital semicircles, **C.** Lateral view, supralabial and infralabial scales to centre of eye

Identification

These individuals were identified as *A. limon* by having mostly green dorsal colouration, smooth ventral scales, dewlap in males light tan or yellow with green light transverse scales, interparietal scale separated from supraorbital semicircles by

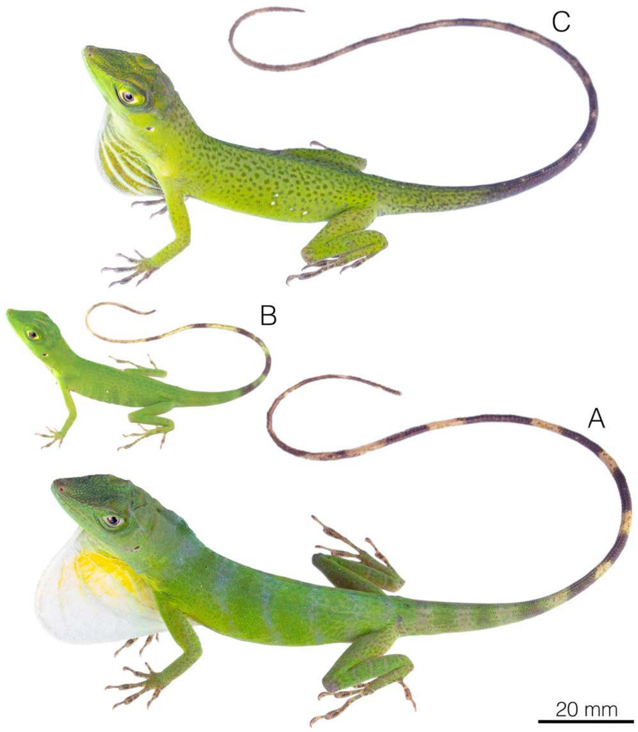

Figure 3. Colouration in life of *Anolis limon* from Falan, Tolima - **A.** Adult male (CZUT-R 797), **B.** Juvenile female (CZUT-R 805) and **C.** Adult female (CZUT-R 799)

2–4 scales and 2–3 scales between supraorbital semicircles (Velasco & Hurtado-Gomez, 2014). However, we observed some variation in these meristic characters and body size, in comparison to other reported data for this species (Table 1, Figs. 2 & 3).

Colouration in life (Fig. 3)

The dorsal colouration pattern observed in adult females was similar to that described by Velasco & Hurtado-Gomez (2014). Under non-stressful conditions, the males displayed faint and slightly bluish bands on a green background (Fig. 3A). After the induction of stress, the aforementioned light bands underwent a transformation, taking on a pale green hue, while the inter-band spaces transitioned to a black colouration. This stress-induced colouration pattern aligns with the described pattern in life for males (Velasco & Hurtado-Gomez, 2014). The juvenile female (Fig. 3B) has a similar dorsal pattern to that of adult females (Fig. 3C), although with fewer black spots. This pattern consists of dark spots and a few lateral white spots on a light green background colour. Nevertheless, the dewlap in juveniles was greenish-yellow, whereas in adult females, it exhibited a fading green colour.

Hemipenial morphology (n = 2, Fig. 4). Moderately bilobed with the sulcus spermaticus bifurcating at the base of lobes. The branches of the sulcus spermaticus continue to the tips of lobes where it opens into a broad naked area. The sulcal lips in the truncus are poorly developed and the sulcus spermaticus wide. Surface of lobes strongly calyculate. The asulcate process is sub-triangular and well-developed, beginning within the crotch and extending to less than half of the truncus, covered by fused calyces that transform into transverse folds, with a more elevated medial portion.

Natural history and behaviour notes

All individuals were caught at night, sleeping on leaves of *Carludovica palmata* or *Cyathea* sp, mostly at heights between 1.60 m to 2 m above ground, although one individual was observed at 6 m. During the day, a female was perching on a leaf of *C. palmata*. One juvenile was collected in October 2020, and two more juveniles were observed in June 2023. A female captured in October 2020 (CZUT-R 801) deposited an egg inside the capture container and when the preserved specimen was examined another egg was detected. In addition, two collected females also contained two eggs, one in each oviduct, while another female only contained one egg. Some individuals emitted a low squeak when caught, while others attempted to bite. Additionally, all individuals changed their colour to a brown tone when captured or stressed.

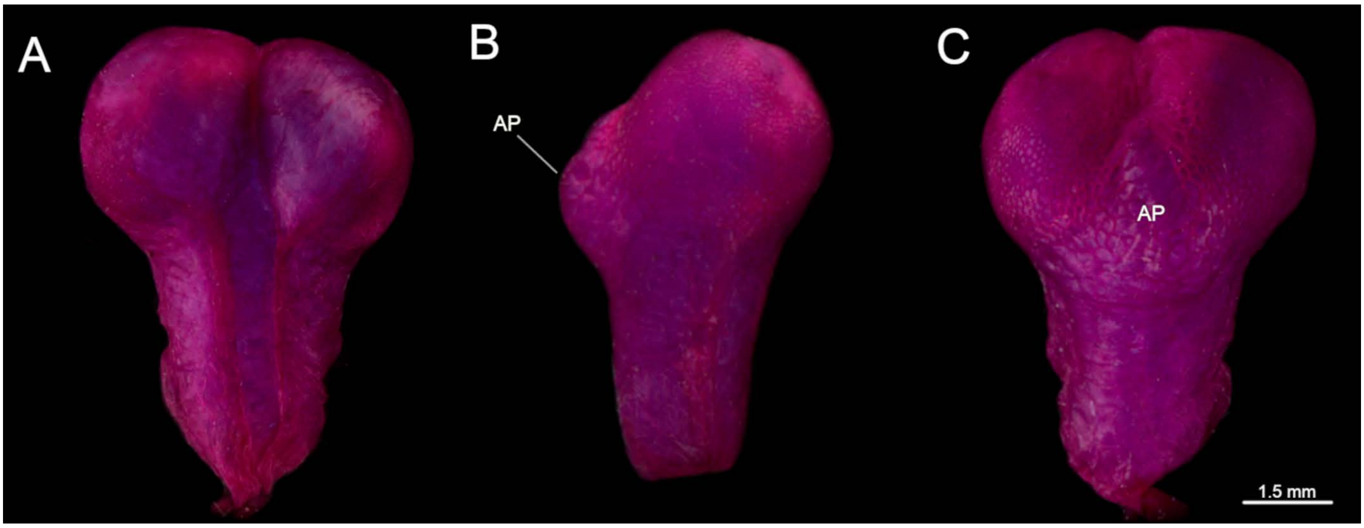

Figure 4. Hemipene of *Anolis limon* (CZUT-R 797), AP = Asulcate process

Table 1. Variation in meristic characters and body size in *Anolis limon*

Characters	**Velasco & Hurtado-Gómez (2014) (n = 6)**	**Current study (n = 10)**
Postrostrals	5–7	7–9
Postmentals (Fig. 2A)	6–7	6–8
Scales between interparietal scale and supraorbital semicircles (Fig. 2B)	2–4	1–3
Scales between supraorbital semicircles (Fig. 2B)	2–3	1–2
Supralabials to centre of eye (Fig. 2C)	8–9	8–10
Infralabials to centre of eye (Fig. 2C)	7–9	7–10
Lamellae under third and four phalanges of fourth toe	20–22	20–23
SVL (mm)	Males = 74.5–78.6 Females = 71.2–81.8	Males = 76.2–87.1 Females = 76.1–85.3 Juvenile = 46.2

DISCUSSION

Anolis limon had been only known in the Departments of Antioquia and Caldas (Rojas-Morales et al., 2019; Velasco & Hurtado-Gómez, 2014), from 520 to 1800 m a.s.l. (Fig. 1). Therefore, the new records reported here extend the geographical distribution of this species to the department of Tolima, 64 km south-west in a straight line from its closest previous locality (Norcasia, Caldas). Additionally, these new localities are outside of the potential distribution calculated for this species (Fig. 1) (Moreno-Arias et al., 2021). The most similar species to *A. limon* are *Anolis ibanezi* and *Anolis purpurecens* (*purpurecens* = *chocorum*), but *A. limon* may be distinguished from them by having an orange dewlap with white transverse scales in males (Velasco & Hurtado-Gomez, 2014). Particularly, in the department of Tolima, the most similar species recorded are *Anolis fraseri* and *Anolis frenatus*. However, *A. limon* has a medium size (SVL < 90 mm; SVL > 100 mm in *A. frenatus*), smooth head scales (rugose or keeled head scales in *A. frenatus*), and granular posterior superciliary scales (smooth and squarish posterior supraciliary scales in *A. fraseri*) (Williams, 1988).

The differences in body size and meristic data between the populations of *A. limon* (Table 1) may be attributed to microenvironmental factors, such as temperature, precipitation and latitude, since these characters are usually adaptive (Calsbeek et al., 2006; Malhotra & Thorpe, 1991). Variations in other characters, such as the dewlap, have been also related to abiotic and biotic variables (Baeckens et al., 2018; Nicholson et al., 2007; Vanhooydonck et al., 2009). Nevertheless, we did not observe any differences in this trait between the original description and the new specimens reported here. Regarding the hemipenial morphology, we provide the first description of the hemipenis of *A. limon*. As yet there is no detailed description of hemipenis for closely related species to *A. limon* (*A. ibanezi* and *purpurescens*); however, *A. limon* shares a bilobed condition with *A. ibanezi*, as indicated by Batista et al. (2015).

The municipalities of Falan and Armero, in the Tolima department, do not belong to the choco-magdalena biogeographic province (Hernández-Camacho et al., 1992). However, in these localities there are several species typical of this province, such as birds (*Capito hypoleucus*, *Habia gutturalis*, *Discosura conversii*), snakes (*Tantilla alticola*) and the lizard studied here (*A. limon*). Some authors suggest a potential extension of this biogeographic province to the south of Tolima (Chaparral) (Acosta-Galvis et al., 2006). Therefore, the new records of *A. limon* in the Tolima department provide evidence supporting the possibility that the limits of this biogeographic province in the Magdalena Valley are more extensive. Given the decline of several species from this province in the Tolima region over the last decade (such as *Trogon cupreicauda*, *Crypturellus erythrops solitarius* and *Crax alberti*) it is likely that threats such as deforestation, agricultural practices, hunting, and the absence of protected areas, may pose a risk to the conservation of *A. limon*.

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REFERENCES

Acosta-Galvis, A.R., Huertas-Salgado, C. & Rada, M. (2006). Aproximación al conocimiento de los anfibios en una localidad del Magdalena medio (departamento de Caldas, Colombia). *Revista de la Academia Colombiana de Ciencias Exactas, Fisicas y Naturales* 30(115): 291–303.

Angiolella, A.B., Klaczko, J., Rodrigues, M.T. & Avila-Pires, T. (2016). Hemipenial morphology and diversity in South American anoles (Squamata: Dactyloidae). *Canadian Journal of Zoology* 94(4): 251−256.

Angulo, A., Rueda-Almonacid, J.V., Rodríguez-Mahecha, J.V. & La Marca, E. (2006). Técnicas de Inventario y Monitoreo para los Anfibios de la Región Tropical Andina. Bogota: Conservación Internacional. 300 pp.

Baeckens, S., Driessens, T. & Damme, R.V. (2018). The brown anole dewlap revisited: do predation pressure, sexual selection, and species recognition shape among-population signal diversity? *PeerJ* 6: e4722. https://doi.org/10.7717/peerj.4722.

Batista, A., Vesely, M., Mebert, K., Lotzkat, S. & Köhler, G. (2015). A new species of *Dactyloa* from eastern Panama, with comments on other *Dactyloa* species present in the region. *Zootaxa* 4039(1): 57–84. https://doi.org/10.11646/zootaxa.4039.1.2.

Calsbeek, R., Knouft, J.H. & Smith, T.B. (2006). Variation in scale numbers is consistent with ecologically based natural selection acting within and between lizard species. *Evolutionary Ecology* 20(4): 377–394. https://doi.org/10.1007/s10682-006-0007-y.

Gallego, O., Quevedo, A., Luna, V. & Figueroa, W. (2008). Falán, cuna de la vida. Libro Pedagógico de Educación Ambiental del Municipio de Falan Departamento del Tolima. Guía de Campo. Ibagué (Tolima). Colombia.

Harvey, M.B. & Embert, D. (2008). Review of Bolivian *Dipsas* (Serpentes: Colubridae), with comments on other South American species. *Herpetological Monographs* 22(1): 54–105.

Hernández-Camacho, J., Hurtado, A., Ortiz, R. & Walschburger, T. (1992). Unidades biogeográficas de Colombia. In *La Diversidad Biológica Iberoamericana I*. 105–151 pp. Xapala, Mexico: Acta Zoologica Mexicana.

Klaczko, J., Ingram, T. & Losos, J. (2015). Genitals evolve faster than other traits in *Anolis* lizards. *Journal of Zoology* 295(1): 44–48. https://doi.org/10.1111/jzo.12178.

Köhler, G. (2014). Characters of external morphology used in *Anolis* taxonomy - Definition of terms, advice on usage, and illustrated examples. *Zootaxa* 3774(3): 201–257.

Köhler, G., Ponce, M., Sunyer, J. & Batista, A. (2007). Four new species of Anoles (Genus *Anolis*) from the serrania de Tabasara, west-central Panama (Squamata: Polychrotidae). *Herpetologica* 63(3): 375–391. https://doi.org/10.1655/0018-0831(2007)63[375:FNSOAG]2.0.CO;2.

Leal, M. & Losos, J.B. (2000). Behavior and Ecology of the Cuban «Chipojos Bobos» *Chamaeleolis barbatus* and *C. porcus*. *Journal of Herpetology* 34(2): 318–322. https://doi.org/10.2307/1565435.

Llano-Mejía, J., Cortés-Gómez, Á.M. & Castro-Herrera, F. (2010). Lista de anfibios y reptiles del departamento del Tolima, Colombia. *Biota colombiana* 11(1 y 2).

Moreno-Arias, R.A. & Calderón-Espinosa, M.L. (2016). Patterns of morphological diversification of mainland *Anolis* lizards from northwestern South America. *Zoological Journal of the Linnean Society* 176: 632–647.

Moreno-Arias, R., Velasco-Vinasco, J. & Olaya-Rodríguez, M.H. (2019). Modelo de distribución de *Anolis limon* ID HER-377. Instituto Alexander von Humboldt. http://biomodelos.humboldt.org.co/species/visor?species_id=7766.

Moreno-Arias, R.A. et al. (2021). Atlas de la Biodiversidad de Colombia. *Anolis*. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá D.C., Colombia. 72 pp.

Malhotra, A. & Thorpe, R.S. (1991). Microgeographic variation in *Anolis oculatus*, on the island of Dominica, West Indies. *Journal of Evolutionary Biology* 4(2): 321–335. https://doi.org/10.1046/j.1420-9101.1991.4020321.x.

Myers, C.W., Williams, E.E. & McDiarmid, R.W. (1993). A new anoline lizard (Phenacosaurus) from the highland of Cerro de la Neblina, southern Venezuela. *American Museum novitate*, no. 3070.

Nicholson, K.E., Harmon, L.J. & Losos, J.B. (2007). Evolution of *Anolis* lizard dewlap diversity. *PLoS ONE* 2(3): e274. https://doi.org/10.1371/journal.pone.0000274.

Ramírez-Chaves, H.E., Arias-Monsalve, H.F., Henao-Osorio, J., Mejía-Fontecha, I.Y., Usama Suarez, L.A., Ramírez-Castaño, V.A. & Rojas-Morales, J.A. (2021). Colección de reptiles no aves (Reptilia), Museo de Historia Natural de la Universidad de Caldas, Colombia. *Biota colombiana* 22(2): 173–181.

Rojas-Morales, J.A., Marín-Martínez, M. & Zuluaga-Isaza, J.C. (2019). Rediscovery of the enigmatic forest racer snake, *Dendrophidion boshelli* Dunn, 1944 (Serpentes, Colubridae): actions for the conservation of a critically endangered species. *Neotropical Biology and Conservation* 14(4): 577–589. https://doi.org/10.3897/neotropical.14.e39572.

Savage, J.M. (1997). On terminology for the description of the hemipenes of squamate reptiles. *The Herpetological Journal* 7(1): 23–25.

Uetz, P., Freed, P., Aguilar, R., Reyes, F., Kudera, J. & Hošek, J. (Eds.) (2024). The Reptile Database. http://www.reptile-database.org. Accessed on 6 January 2024.

Vanhooydonck, B., Herrel, A., Meyers, J.J. & Irschick, D.J. (2009). What determines dewlap diversity in *Anolis* lizards? An among-island comparison. *Journal of Evolutionary Biology* 22(2): 293–305. https://doi.org/10.1111/j.1420-9101.2008.01643.x.

Velasco, J.A. & Hurtado-Gómez, J.P. (2014). A new green anole lizard of the «*Dactyloa*» clade (Squamata: Dactyloidae) from the Magdalena river valley of Colombia. *Zootaxa* 3785: 201–216. https://doi.org/10.11646/zootaxa.3785.2.4.

Williams, E.E. (1988). New or problematic *Anolis* from Colombia. V. *Anolis danieli*, a new species of the latifrons species group and a reassessment of *Anolis apollinaris* Boulenger, 1919. *Breviora* 489.

Zaher, H. (1999). Hemipenial morphology of the South American xenodontine snakes: with a proposal for a monophyletic Xenodontinae and a reappraisal of colubroid hemipenes. *Bulletin of the American Museum of Natural History*, no. 240: 169.

Zaher, H. & Prudente, A.L.C. (2003). Hemipenes of *Siphlophis* (Serpentes, Xenodontinae) and techniques of hemipenial preparation in snakes: a response to Dowling. *Herpetological Review* 34(4): 302–306.

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RESEARCH ARTICLE

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How many Data Deficient amphibians are threatened? IUCN Red List assessments for amphibian species previously classed as Data Deficient

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ABSTRACT – At the time of our research in 2022, 16.4% of amphibian species on the IUCN Red List were assessed as Data Deficient (DD). There is minimal funding allocated to the research and reassessment of DD taxa, this prevents them from being prioritised for conservation. We identified 656 non-DD amphibian species that were previously assessed as DD and used their subsequent assessment trajectories to predict the extinction risk of remaining DD taxa. Assuming similarity of the distribution of these taxa between extinction risk categories to those of currently DD species, we compared this dataset with the risk category distribution of assessed amphibians that had never been assessed as DD. Previously DD amphibians, when compared to those that were never DD, were found to be more threatened (52.1% vs. 39.6%) and less likely to be non-threatened (22.4% vs. 60.0%). When explored further at the level of Order, more previously DD amphibians in the Order Gymnophiona were reassessed as 'Near Threatened', more Caudata 'Critically Endangered' with fewer 'Least Concern', and more Anura 'Vulnerable' and 'Endangered' with fewer 'Least Concern' than counterparts that were never assessed as DD. Based on these previously-DD amphibian data, we estimated that around half (49.6%, n = 592) of currently DD amphibians are likely threatened by extinction. Our approach arrives at similar conclusions to authors using other approaches and bolsters the argument that conservationists and funding organisations should implement recommendations to address concerns for DD amphibians, especially DD Caudata.

INTRODUCTION

Amphibians are one of the world's most threatened Classes of vertebrates (Howard & Bickford, 2014; González-del-Pliego et al., 2019; Luedtke et al., 2023), with 41% of species assessed by the International Union for Conservation of Nature (IUCN) facing risk of extinction when this research was conducted (IUCN, 2022). The drivers of extinction are multifaceted, interlinked and often anthropogenic in nature (Young et al., 2004; Hoffmann et al., 2010; Howard & Bickford, 2014; Grant et al., 2016; Ortega-Andrade et al., 2021; Luedtke et al., 2023).

The IUCN Red List of Threatened Species (hereafter the "Red List") assesses the extinction risk of species that have been described by science. These assessments underpin conservation prioritisation tools and influence policy and conventions to determine which species receive conservation attention (Mace et al., 2008; Parsons, 2016; Tapley et al., 2018). The Red List has become the most widely accepted comprehensive international database for the assessment of individual species and their extinction risks (Mace et al., 2008; Hoffmann et al., 2010). As well as assessing the extinction risk to specific species, the Red List authority aims to increase the proportion of assessed species in order to monitor the status of the world's biodiversity (Bland et al., 2017). However, if there is insufficient information with which to assess the extinction risk posed to a species, it is usually assessed as 'Data Deficient' (IUCN, 2012). At the time of conducting this research, 16.4% (1193 of 7296 assessed amphibian species) were assessed as Data Deficient (DD) (IUCN, 2022). Although the current proportion of DD species is smaller than it has been in previous years (>25% in 2017; Bland et al., 2017), concerns remain because it is thought that DD taxa have a higher average extinction risk than assessed species (Morais et al., 2013; Howard & Bickford, 2014; Tapley et al., 2018). Nevertheless, conservation prioritisation tools such as the EDGE of Existence Programme (Isaac et al., 2012; 2018; Gumbs et al., 2018), as well as regional conservation policy, typically deprioritise DD taxa for research and funding due to their uncertain extinction risk (Howard & Bickford, 2014; Bland et al., 2017).

Attempts to quantify the probable extinction risk categories for DD amphibian species have been made using species trait, phylogenetic and distribution data (Morais et al., 2013; Howard & Bickford, 2014; González-del-Pliego et al., 2019). These studies found that overall, amphibians are at a higher risk of extinction, and DD species are more likely to be threatened based on their traits, distribution and time since being described.

We adopted a different approach to estimating the proportions of DD species that may fall into each Red List category, using the eventual category into which previously DD species were placed after reassessment to inform the likely designation of species still assessed as DD.

METHODS

Data sources

Extinction risk category terminology follows the IUCN Red List (IUCN, 2012); Least Concern (LC); Near Threatened (NT) Vulnerable (VU); Endangered (EN); Critically Endangered (CR); Extinct in the Wild (EW); Extinct (EX). Using the Red List database (IUCN, 2022), we reviewed the assessment information for all 7296 IUCN amphibian extinction risk assessments; the assessment information provides the extinction risk according to previously published Red List assessments. For species that were assessed as DD at any point since 2004 onwards and were subsequently reassessed and allocated to another extinction risk category, we collected the following information: common and scientific name, date of most recent DD assessment, current extinction risk category (as some species were assessed as DD for multiple assessments), and date of assessment for current extinction risk category. This formed our 'focal dataset'. Species that were previously assessed as DD prior to 2004 were excluded from the focal dataset (n = 49), because they were reassessed for the Global Amphibian Assessment of 2004 (Stuart et al., 2004), allowing 2004 to be a baseline for all amphibian species in our investigation. The 'comparison dataset' consisted of assessed amphibian species that had never been assessed as DD from 2004 onwards (i.e. had been assigned an extinction risk category other than DD from initial assessment) and we recorded the following information: common and scientific name, current extinction risk category and date of most recent assessment. Species that were never assessed as DD but previously assessed as "Insufficiently Known" (a category removed after 1994; Groombridge, 1993), were also excluded from both our datasets (n = 10), because the definition did not meet the same criteria as DD (category established in 1994 and used from 1996 onwards (IUCN, 1994; 1996)). Species were retained in our datasets if they were recognised by Frost (2021).

These data were organised by amphibian Order for comparison. The data spanned from 2004 to 2020 as none of the species in our focal dataset was assessed after 2020. Once the data were collected, we enumerated how many species in the focal dataset transitioned from DD to each of the other extinction risk categories. We counted the number of species in each extinction risk category for the comparison dataset.

Statistical analyses

Using R (version 4.2.2; R Core Team, 2022) in R Studio (RStudio Team, 2022), we carried out a Pearson's Chi squared (χ^2) test for Independence, with P value simulation (using 2000 iterations and standardised residuals) to deal with small expected counts (Hope, 1968; Zaiontz, 2021); consequently no degrees of freedom are reported for analysis outcomes. This analysis compared observed counts with the counts expected if focal and comparison data sets came from the same distribution. The Chi squared test was used to make comparisons between our focal and comparison datasets at the level of Class (all amphibian Orders) and Order (Gymnophiona, Caudata and Anura separately).

Post hoc pairwise comparisons were carried out using the Bonferroni method upon any rejection of the null hypothesis, to see which categories were responsible for deviation from the null hypothesis.

Estimation of extinction risk for currently DD amphibians

The current distribution of all IUCN assessed amphibians in general, and the counts from our focal and comparison dataset distributions, were used to estimate how many of the 1193 DD species could be at potential risk of extinction. We calculated the percentage of amphibians that were potentially threatened (CR, EN, VU) and extinct (EW and EX) using the proportions calculated in each dataset (current, focal and comparison distributions) to observe the difference in estimates based on the different distributions. The following equation was used to estimate how many species would be assigned to a single extinction risk category within a single Order, repeated for each dataset:

$$\frac{no.\,of\ species\ in\ risk\ category\ within\ Order}{total\ no.\,of\ species\ within\ Order} \times no.\,of\ currently\ DD\ species\ within\ Order$$

For proportion threatened, our study reports the mid-point percentages (i.e. (CR+EN+VU)/(Assessed–EX–DD)), as recommended by the IUCN Guidelines for Reporting on Proportion Threatened (IUCN, 2016), as opposed to the lower-bound percentages (i.e. (CR+EN+VU)/(Assessed)).

RESULTS

Chi squared analysis

For amphibians overall, a significant difference was identified in the distribution of amphibians amongst the IUCN extinction risk categories between the focal and comparison datasets (χ^2 = 55.2, p = 0.0005). The post-hoc tests showed that fewer than expected previously-DD amphibians were reassessed as LC based on comparison data ($p < 0.0001$), and more were reassessed as EN ($p < 0.0001$); there were no differences for other categories.

Further comparisons of the amphibian Orders showed a significant difference in the distribution of Gymnophiona amongst the IUCN extinction risk categories between focal and comparison datasets (χ^2 = 10.3, p = 0.0345). The post-hoc tests showed that more previously-DD Gymnophiona were reassessed as NT than expected, based on comparison data (p = 0.0373), with no other differences identified.

A significant difference in the distribution of Caudata between extinction risk categories was also found (χ^2 = 46.5, p = 0.0005), and post-hoc tests showed that fewer than the expected previously-DD caudates were reassessed as LC (p = 0.0028), based on the comparison data, with more reassessed as CR ($p < 0.0001$); no other differences were found.

A significant difference in distribution of Anura was found (χ^2 = 64.0, p = 0.0005), and the post-hoc tests showed that fewer previously-DD Anura were reassessed as LC ($p < 0.0001$) than the expected, based on comparison data, with more reassessed as VU (p = 0.0067) and EN ($p < 0.0001$).

Table 1. Number of amphibian species in each dataset by IUCN extinction risk category. G, Gymnophiona; C, Caudata; A, Anura; DD, Data Deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; EN, Endangered; CR, Critically Endangered; EW, Extinct In The Wild; EX, Extinct. Value in bold indicates absolute total in each dataset and overall percentage threatened in each dataset. Threatened categories include VU, EN and CR. Proportion of threatened is calculated using mid-point percentages (i.e. (CR+EN+VU)/(Assessed–EX–DD), which excludes the DD and EX categories from the total) as stated in the IUCN Guidelines for Reporting on Proportion Threatened (IUCN, 2016).

	Current IUCN Distribution				**Focal Dataset**				**Comparison Dataset**			
Category	**G**	**C**	**A**	**Total**	**G**	**C**	**A**	**Total**	**G**	**C**	**A**	**Total**
DD	99	50	1044	1193								
LC	69	184	2907	3160	15	3	245	263	54	180	2640	2874
NT	3	64	351	418	3	2	46	51	0	58	300	358
VU	4	118	608	730	2	3	91	96	2	112	510	624
EN	10	161	914	1085	3	17	150	170	7	143	757	907
CR	3	121	549	673	1	25	49	75	2	94	493	589
EW	0	0	2	2	0	0	0	0	0	0	2	2
EX	0	3	32	35	0	0	1	1	0	3	31	34
Total	188	701	6407	**7296**	24	50	582	**656**	65	590	4733	**5388**
Proportion threatened	19.1%	61.7%	38.8%	**41.0%**	25%	90%	49.8%	**52.1%**	16.9%	59.5%	37.4%	**39.6%**

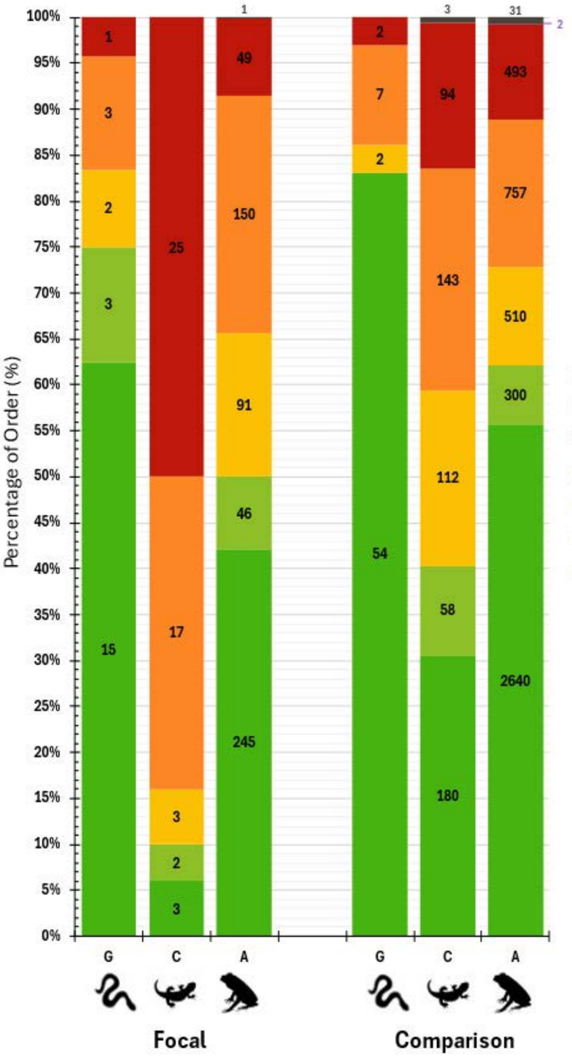

Figure 1. Distribution of focal and comparison datasets into the IUCN extinction risk categories by amphibian Order. Focal n = 656, Comparison n = 5388. Abbreviations: LC - Least Concern, NT - Near Threatened, VU - Vulnerable, EN - Endangered, CR - Critically Endangered, EW - Extinct in the Wild, EX - Extinct. Values on bars represent the number of species.

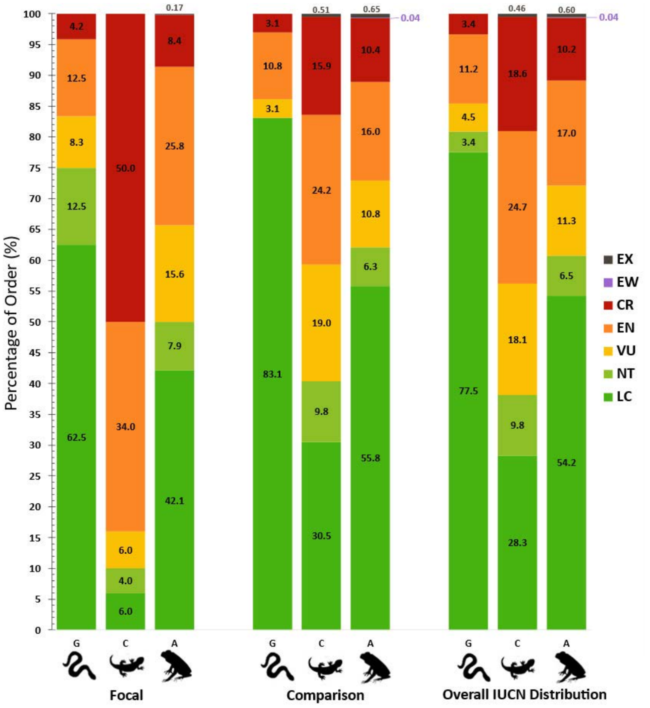

Figure 2. Estimates of the number of species in each IUCN extinction risk category by Order and dataset for currently DD Amphibia. Overall DD amphibians n = 1193; Gymnophiona n = 99, Caudata n = 50, Anura n = 1044. Values on bars represent percentages. Abbreviations: C - Caudata, G - Gymnophiona, A - Anura, DD - Data Deficient. For other abbreviations, see legend to Figure 1.

Differences in the proportion of threatened amphibians among datasets

For amphibians that were previously assessed as DD, 52.1% (n = 341) were subsequently reassessed as threatened (CR, VU, and EN) (Table 1 and Fig. 1). For species that were never DD, the proportion of threatened amphibians was 39.6% (n = 2120). At the Order level Caudata were proportionately the most threatened and Gymnophiona were the least threatened among all distributions (Table 1 and Fig. 1).

Estimates of DD species potentially threatened

Based on our focal data estimates (Fig. 2), 49.6% (n = 592) of currently DD amphibian species are suspected to be threatened, 12.6 percentage points more than if estimates are based on species that were never DD (37.1%, n = 442), and 11.1 percentage points more than if estimates are based solely on the overall IUCN distribution (38.5%, n = 460). A higher proportion of DD Caudata are suspected to be threatened based on previously DD Caudata (90%, n = 45) than compared to estimates based on previously non-DD Caudata (59.7%, n = 30). Half (50%, n = 522) of the currently DD Anura are suspected to be threatened based on previously DD species, compared to 37.9% (n = 395) threatened based on Anura that were never assessed as DD. A quarter (25%, n = 25) of DD Gymnophiona are suspected to be threatened based on previously DD Gymnophiona, compared to 16.9% (n = 17) based on those that were never assessed as DD. Overall, using our estimates from previously DD species, the projected total estimates for each category would be LC = 3664 (50.2%), NT = 515 (7.06%), VU = 905 (12.4%), EN = 1383 (19%), CR = 790 (10.8%), EW = 2 (0.027%), EX = 37 (0.51%). This brings the overall proportion of threatened amphibians up to 42.2%, with specifically Gymnophiona increasing to 22.2%, Caudata to 63.5% and Anura to 40.4%.

DISCUSSION

Estimates using our data and approach suggest that, based on the assessment trajectories of previously DD species, DD amphibians are more likely to be subsequently assigned to threatened categories than if their extinction risk category distribution was the same as for species never assessed as DD. Previously DD amphibians were specifically more likely to be EN and less likely to be LC than species that were never DD, providing cause for concern for amphibians that are currently assessed as DD. Other estimations based on distribution and extinction risk data (Howard & Bickford, 2014), have shown that 63% of DD species were suspected to be threatened in 2014, out of the 1249 assessed as DD at the time. This estimate is greater than our estimates (49.6%). Based on distribution, extinction risk, phylogenetic, and species-trait data, González-del-Pliego et al. (2019) estimated 47% of DD species to be threatened in 2019, which is very similar to our estimate and more comparable in timepoint. Machine learning-derived probabilities of DD amphibian species being threatened with extinction found that 85% of the 1130 DD amphibians were threatened with extinction (Borgelt et al., 2022), a figure much greater than our estimate. Ultimately, all estimates show that DD species are suspected to be more threatened.

Data from the recently published Global Amphibian Assessment II show that Caudata are, on average, more threatened than both Anura and Gymnophiona (Re:wild, Synchronicity Earth, IUCN SSC Amphibian Specialist Group, 2023). Our findings support this; we found previously DD Caudata to be more threatened, compared to non-DD Caudata, with a higher proportion of threatened (90%) than Gymnophiona and Anura. Additionally, previously DD Caudata show a 28.3% difference in proportion of threatened than the overall IUCN assessed, in comparison to only 5.9% for Gymnophiona, and 11% for Anura. Therefore, IUCN best estimates heavily underestimate the proportion of DD Caudata presumed threatened based on extinction risk status.

We found that previously DD Anura were more threatened than previously non-DD Anura. Morais et al. (2013), focusing specifically on Brazilian Anuran species, estimated 57% (37 of 65) of DD species to be threatened (from those not reassessed as DD), which is slightly higher than our estimate, but overall supports that DD Anura are proportionately more threatened than non-DD Anura. A recent national Red List assessment for amphibians in Ecuador (Ortega-Andrade et al., 2021) reported 72.7% of Caudata and 56.7% of Anura as threatened, affirming our trends for these Orders, although only on a national scale. This study also reported a much larger proportion of threatened Gymnophiona (60.9%) compared to our dataset (16.9 – 25%). This could be due to the high proportion of DD and out-of-date assessments for Gymnophiona as they are more cryptic in nature, making them rarer to encounter during surveys (Gower & Wilkinson, 2005). However, the density of DD species is known to differ geographically, for example, 24% of amphibians in Indonesia are assessed as DD and there are no amphibians assessed as DD in Europe (Re:wild, Synchronicity Earth, IUCN SSC Amphibian Specialist Group, 2023).

The extinction risk status of a species is important for conservation planning and prioritisation (Morais et al., 2013). Therefore, reassessment of DD species is important in preventing silent extinctions (Liu et al., 2022). Also, recommendations for improving the DD category should be implemented (Parsons, 2016; Bland et al., 2017). This is increasingly important given the high rate of amphibian species descriptions (Tapley et al., 2018; Liu et al., 2022) and the effect of species splitting on estimated population size (Funk et al., 2012). Funding for reassessment of these species is important, but only a few organisations award funding specifically to DD species, e.g. the Mohamed Bin Zayed Species Conservation Fund, which has awarded 4.5% of grant funding to DD species (0.36% to Amphibians) (The Mohamed bin Zayed Species Conservation Fund, 2024). More organisations should take the initiative to invest additional time, money and research into this field of work. Previously, there was less incentive for funding organisations to explore DD biodiversity (Howard & Bickford, 2014), but our study, among others, provides evidence for the need to focus additional attention on DD amphibians and highlights some gaps requiring research. At least it is encouraging that the proportion of species assessed as DD has decreased from 23% from the first Global Amphibian Assessment in 2004 to 11% in the second assessment in 2023 (Re:wild, Synchronicity Earth, IUCN SSC Amphibian Specialist Group, 2023).

The methods used in this work are relatively simple compared with previous analyses, which used species life history and distribution traits to predict extinction risk of DD species (Howard & Bickford, 2014; González-del-Pliego et al., 2019). Our approach makes use of historic Red List data recording assessment trajectories of species previously assessed as DD, which was not accounted for by previous analyses, and may provide a framework that could be readily applied to other taxa. However, an inherent assumption of this approach is that species in the focal and comparison datasets come from the same distribution of extinction risk, which is a limitation of our analyses.

In conclusion, we used novel methodology to independently estimate extinction risk among DD amphibians. Our findings add to, and broadly agree with, the existing body of evidence that DD amphibians are more likely to be threatened than might be estimated by simple extrapolation of extinction risk category proportions for assessed, non-DD taxa. This finding highlights the need for greater investment in the study and subsequent reassessment and conservation of DD amphibians, particularly Caudata.

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REFERENCES

Bland, L.M., Bielby, J., Kearney, S., Orme, C.D.L., Watson, J.E.M. & Collen, B. (2017). Toward reassessing data-deficient species. *Conservation Biology* 31: 531–539.

Borgelt, J., Dorber, M., Høiberg, M.A. & Verones, F. (2022). More than half of data deficient species predicted to be threatened by extinction. *Communications Biology* 5: 679.

Frost, D.R. (2021). Amphibian Species of the World: An Online Reference. Version 6.1. https://amphibiansoftheworld.amnh.org/index.php. Accessed on 20 May 2022.

Funk, W.C., Caminer, M. & Ron, S.R. (2012). High levels of cryptic species diversity uncovered in Amazonian frogs. *Proceedings of the Royal Society B: Biological Sciences* 279: 1806–1814.

González-del-Pliego, P., Freckleton, R.P., Edwards, D.P., Koo, M.S., Scheffers, B.R., Pyron, R.A. & Jetz, W. (2019). Phylogenetic and trait-based prediction of extinction risk for Data-Deficient amphibians. *Current Biology* 29: 1557–1563.e3.

Gower, D.J. & Wilkinson, M. (2005). Conservation biology of caecilian amphibians. *Conservation Biology* 19: 45–55.

Grant, E.H.C., Miller, D.A.W., Schmidt, B.R., Adams, M.J. et al. (2016). Quantitative evidence for the effects of multiple drivers on continental-scale amphibian declines. *Scientific Reports* 6: 25625.

Groombridge, B. (1993). 1994 IUCN Red List of Threatened Animals, Gland, Switzerland and Cambridge, UK: IUCN. 348 pp.

Gumbs, R., Gray, C.L., Wearn, O.R. & Owen, N.R. (2018). Tetrapods on the EDGE: Overcoming data limitations to identify phylogenetic conservation priorities. *PLoS One* 13: p.e0194680.

Hoffmann, M., Hilton-Taylor, C., Angulo, A. et al. (2010). The impact of conservation on the status of the world's vertebrates. *Science* 330: 1503–1509.

Hope, A.C.A. (1968). A simplified Monte Carlo significance test procedure. *Journal of the Royal Statistical Society* 30: 582–598.

Howard, S.D. & Bickford, D.P. (2014). Amphibians over the edge: silent extinction risk of Data Deficient species. *Diversity and Distributions* 20: 837–846.

Isaac, N.J.B., Redding, D.W., Meredith, H.M. & Safi, K. (2012). Phylogenetically-informed priorities for amphibian conservation. *PLoS ONE* 7: e43912.

Isaac, N.J. & Pearse, W.D. (2018). The use of EDGE (Evolutionary Distinct Globally Endangered) and EDGE-like metrics to evaluate taxa for conservation. In *Phylogenetic Diversity: Applications and Challenges In Biodiversity Science*. 27–39 pp. Scherson, R. & Faith, D. (Eds.). Cham: Springer.

IUCN (1994). IUCN Red List Categories and Criteria: Version 2.3. Gland, Switzerland and Cambridge, UK: IUCN. 18 pp.

IUCN (1996). 1996 LUCN Red List of Threatened Animals. Gland, Switzerland and Cambridge, UK: IUCN. 452 pp.

IUCN (2012). IUCN Red List Categories and Criteria: version 3.1. 2nd ed. Gland, Switzerland and Cambridge, UK: IUCN. p. iv + 32pp.

IUCN (2016). Annex 1. Guidelines for Reporting on Proportion Threatened, Version 1.1, In *Guidelines for Appropriate Uses of IUCN Red List Data* (Version 3.0). Gland, Switzerland and Cambridge, UK: IUCN. 5 pp.

IUCN (2022). The IUCN Red List of Threatened Species. Version 2021-3. https://www.iucnredlist.org/. Accessed on 1 February 2022.

Liu, J., Slik, F., Zheng, S. & Lindenmayer, D.B. (2022). Undescribed species have higher extinction risk than known species. *Conservation Letters* 15: e12876.

Luedtke, J.A., Chanson, J., Neam, K., Hobin, L. et al. (2023). Ongoing declines for the world's amphibians in the face of emerging threats. *Nature* 622: 308–314.

Mace, G.M., Collar, N.J., Gaston, K.J., Hilton-Taylor, C., Akçakaya, H.R., Leader-Williams, N., Milner-Gulland, E.J. & Stuart, S.N. (2008). Quantification of extinction risk: IUCN's system for classifying threatened species. *Conservation Biology* 22: 1424–1442.

MBZSC (2022). Supported Grants [online], The Mohamed bin Zayed Species Conservation Fund. https://www.speciesconservation.org/case-studies-projects/small-grants. Accessed on 25 January 2024.

Morais, A.R., Siqueira, M.N., Lemes, P., Maciel, N.M., De Marco, P. & Brito, D. (2013). Unraveling the conservation status of Data Deficient species. *Biological Conservation* 166: 98–102.

Ortega-Andrade, H.M., Rodes Blanco, M., Cisneros-Heredia, D.F., Guerra Arévalo, N. et al. (2021). Red List assessment of amphibian species of Ecuador: A multidimensional approach for their conservation. *PLoS ONE* 16: e0251027.

Parsons, E.C.M. (2016). Why IUCN Should replace "Data Deficient" conservation status with a precautionary "Assume Threatened" status—A cetacean case study. *Frontiers in Marine Science* 3: 193.

RStudio Team (2022). RStudio: integrated development environment for R, available: http://www.rstudio.com/.

Accessed 30 March 2022.

Re:wild, Synchronicity Earth & IUCN SSC Amphibian Specialist Group (2023). State of the World's Amphibians: The second global amphibian assessment. Texas, USA: Re:wild. 47 pp.

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodrigues, A.S.L., Fischman, D.L. & Waller, R.W. (2004). Status and trends of amphibian declines and extinctions worldwide. *Science* 306: 1783–1786.

Tapley, B., Michaels, C.J., Gumbs, R., Böhm, M., Luedtke, J., Pearce-Kelly, P. & Rowley, J.J.L. (2018). The disparity between species description and conservation assessment: A case study in taxa with high rates of species discovery. *Biological Conservation* 220: 209–214.

Young, B.E., Stuart, S.N., Chanson, J.S., Cox, N.A. & Boucher, T.M. (2004). Disappearing Jewels: The Status of New World Amphibians. Arlington: Virginia. 60 pp.

Zaiontz, C. (2021). Simulation Chi-Square Test [online], Real Statistics Using Excel. https://www.real-statistics.com/chi-square-and-f-distributions/simulation-chi-square-test/. Accessed 29 Apr 2022.

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SHORT NOTE

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New herpetological records of *Hyperolius pusillus*, *Psammophis pulcher*, *Malacochersus tornieri* and *Myriopholis macrorhyncha* from three different areas in Kenya

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INTRODUCTION

Kenya is home to a wide variety of herpetofauna, currently harbouring about 110 species of amphibians and 290 species of reptiles (Amphibiaweb, 2023; Malonza & Bwong, 2023; Uetz et al., 2023). Kenyan herpetology has a long history and began receiving attention when Arthur Loveridge became the curator of the Nairobi museum in 1914 (e.g. Loveridge, 1924). Also in more recent decades, the country's herpetofauna has been the subject of considerable research attention which has resulted in the publication of field guides and checklists that provide a clearer understanding of the ecology and distribution of Kenyan species (e.g. Spawls, 1978; Channing & Howell, 2006; Spawls et al., 2018). Nevertheless, it is likely that many new reptile and amphibian populations are yet to be recorded, as are new insights in the role of these species in the specific ecosystems that they inhabit. In this contribution, we share new records regarding range extensions and specific behavioural aspects of four reptile and amphibian species that to the best of our knowledge have either not been documented before or deserve further elaboration.

Between 22 April and 7 May 2023, we undertook a field trip to Kenya, to observe and photograph specific species of reptiles and amphibians in their natural habitats. We visited two areas bordering Tsavo National Park and the vicinity of Lake Baringo. Records were collected during both diurnal and nocturnal visual encounter surveys. To assess whether our records represent distributional range extensions or rarely observed and/or undescribed behaviour, we consulted online repositories of museum collections (CAS Herpetology; Natural History Museum, London; Kenya Virtual Museum Records; Collection Herpetologie-SNSD; Steinhardt Museum of Natural History; ZFMK Herpetology collection; MVZ Herp Collection; Natural History Museum, Rotterdam; University of Florida Herpetology; Amphibians and Reptiles collection at the Natural History Museum of Denmark; Naturalis Biodiversity Centre; NMNH Extant Specimen Records; Museum of Comparative Biology, Harvard; Vertebrate Zoology Division – Herpetology, Yale Peabody Museum; MNHN – Paris; Field Museum of Natural History, Amphibian and Reptile Collection; Collection Herpetology SMF; Herp Specimens; AMNH Herpetology Collection) using the Global Biodiversity Information Facility and checked the relevant literature. Furthermore, we checked online citizen science repositories (i.e. www.inaturalist.org; www.observation.org).

The records presented below comprise range extensions for *Psammophis pulcher* Boulenger, 1895 and *Myrophولis macrorhyncha* (Jan, 1860) and behavioural observations regarding *Malacochersus tornieri* (Siebenrock, 1903) and *Hyperolius pusillus* (Cope, 1862). A full list of herpetological records collected during the surveys as well as more photographs can be found at www.herpsafari.nl. Specific details, e.g. locations, are available upon request.

SPECIES ACCOUNTS

Water lily reed frog - *Hyperolius pusillus* (Cope, 1862)
Records collected (n = ~100)
Taita Taveta County, edge of Tsavo National Park, at one particular location in and around an artificial water basin; 3.78609° S, 38.87059° E; altitude 455 m; recorded on 1 and 2 August 2023, after sunset; no specimens collected.

Comments
A large number of adults, some in amplexus and with clutches of eggs, were found mostly inside the basin. The English name is derived from the fact that this species is commonly found on floating vegetation, such as water lilies (Channing & Rödel, 2019; Malonza & Bwong, 2023). In this case, most individuals were found sitting on water lettuce (*Pistia stratiotes*), which covered the majority of the water surface. We here record a case of predation of a specimen of *H. pusillus* by a spider of the family Pisauridae. The spider is presumed to belong to the genus *Nilus*, but given the poorly resolved taxonomy of this

Figure 1. A specimen of *Hyperolis pusillus* (red arrow) predated by a pisaurid spider at a location on the edge of Tsavo NP

family in Africa, the exact identity is currently uncertain. We observed these spiders actively hunting for prey until one specimen caught an *H. pusillus* and started feeding on it (Fig. 1). This situation was observed for approximately one hour. By then, the frog was still alive, but body tissue around the area of the bite had become fluid. Predation of *Hyperolius* frogs and other frog species in the afrotropics by spiders has been reviewed by Babangenge et al. (2019). They mention that call sites favoured by *H. pusillus* make it particularly vulnerable to predation by pisaurid spiders (Minter et al., 2004), but until now no well-described cases of predation on *H. pusillus* have been published. Sympatric species of reptiles and amphibians that we recorded include *Afrixalus delicatus* Pickersgale, 1984, *Kassina somalica* Scortecci, 1932, *Naja pallida* Boulenger, 1896, *Pelomedusa* cf. *neumanni* Petzold et al., 2014 and *Ptychadena mossambica* (Peters, 1854).

Beautiful sand snake - *Psammophis pulcher* Boulenger, 1895

Records collected (n = 1)

Taita Taveta County, edge of Tsavo National Park, on a location near the village of Maungu; 3.56395° S, 38.75052° E; Altitude 545 m; recorded on 2 May 2023 at 10.45 h; no specimens collected.

Comments

A single adult female was found crawling through dead grass at a location with open woodland. While being handled, it bit two of the authors, which did not result in any symptoms. It was identified based on the following characteristics (Boulenger, 1895; Spawls et al, 2018; Malonza & Bwong, 2023); snout rounded; a long tail that is 36–39% of the total length; pale brownish above, with a fine black-edged brown vertebral line; a black dorsolateral stripe running along the second row of scales and extending to the end of the snout after passing through the eye; underside including the lips cream white; 13 mid-body scale rows; 4th and 5th upper labials touching the eye (Fig. 2). *Psammophis pulcher* is believed to be one of East Africa's rarest snake species, with only very few observations to date (Drewes & Spawls, 1973; Spawls et al, 2018). It was described in 1895 based on a single specimen from the Webbe Shibeli river, Ethiopia (Boulenger, 1895). No more observations were made until 1961, when a second specimen was found at Voi in Tsavo NP, the first record for Kenya. A third and fourth specimen were found in 1972 in eastern Kenya (Ngomeni) and 'Somaliland' (without further data). More recently, seven or eight specimens were found between 2012–2014 at Bisanadi NR close to Meru National Park (Sean Flatt & Mark Flatt, pers. comm.). Hence, this species is known from about a dozen traceable records. Based on the currently known records (Fig. 5), *P. pulcher* is an inhabitant of dry savanna at low altitude. Despite its rarity, it could be quite widespread in eastern Kenya. New records can result in a better understanding and prediction of its actual distribution throughout the country, therefore underlining the importance of recording such observations. The record presented here is the second record for the area of Tsavo NP, extending the distribution approximately 25 km south-east in a straight line from the closest known locality at Voi, which was recorded in 1961. Sympatric species of reptiles and amphibians that we recorded include *Agama lionotus* Boulenger, 1896, *Dendroaspis polylepis* Günther, 1864, *Dispholidus typus* (Smith, 1828) and *Trachylepis quinquetaeniata* (Lichtenstein, 1823).

Pancake tortoise - *Malacochersus tornieri* (Siebenrock, 1903)

Records collected (n = 7)

Kitui County, south of Mwingi National Reserve; altitude 536 m. Recorded on 29 April–1 May 2023 at various times of the day; we have chosen not to share location details to prevent poaching. Detailed information is available upon reasonable request; no specimens collected.

Figure 2. A specimen of *Psammophis pulcher* from a location at the edge of Tsavo NP

Figure 3. An adult (red arrow) and a subadult (blue arrow) *Malacochersus tornieri* sharing their shelter with a subadult *Bitis arietans* (white arrow)

Comments

All the specimens we found were observed hiding in rock crevices. We here discuss one specific record of two *M. tornieri*, an adult and a subadult, sharing the same rock crevice with a subadult puff adder, *Bitis arietans* Merrem, 1820. The rock crevice was situated about 50 cm above ground level. At the same boulder formation, an adult *B. arietans* was found. Both tortoises and the subadult *B. arietans* were found undisturbed and hiding right next to each other – one of the tortoises touching the *B. arietans* - in the same part of the crevice (Fig. 3). The sharing of rock crevices by these two species has been documented before (Malonza, 2003). However, to the best of our knowledge this is the first record that includes a subadult *M. tornieri*. We deem this noteworthy because *B. arietans* is known to feed on tortoises (e.g. Spawls et al., 2018), and in this case would be able to swallow the subadult *M. tornieri*. Therefore, this observation concerns predator and potential prey sharing the same shelter. Sympatric species of reptiles and amphibians that we recorded include *Chamaeleo gracilis* Hallowell, 1844, *Eryx colubrinus* (Linnaeus, 1758), *Heliobolus spekii* (Günther, 1872), *Hemidactylus mabouia* (Moreau de Jonnés, 1818), *Hemidactlyus platycephalus* Peters, 1854, *Hemidactylus squamulatus* Tornier, 1896, *Latastia longicaudata* (Reuss, 1834), *Lygodactylus tsavoensis* Malonza, Bauer, Granthon, Williams & Wojnowski, 2019, *Mochlus sundevalli* (Smith, 1849), *Psammophis punctulatus* Duméril, Bibron & Dumeril, 1854, *Trachylepis brevicollis* (Wiegmann, 1837), *Trachylepis margaritifera* (Peters, 1854), *Tomopterna* cf. *tandyi* Channing & Bogart, 1996 and *Varanus albigularis* Daudin, 1802.

Hook-snouted Worm Snake - *Myriopholis macrorhyncha* (Jan, 1860)

Records collected (n = 2)

Baringo County, on Teddy Bear Island, which is situated in Lake Baringo; 0.601250° N, 36.054778° E; altitude 997 m; 23 and 24 April 2023, after sunset; no specimens collected.

Comments

Both specimens were found out in the open on a woodland trail and tentatively identified as *M. macrorhyncha*. They shared the same characteristics; body cylindrical and thin; head and neck slightly broadened; strongly hooked snout with distinct beak; tail tapering to a small blunt cone; dorsum unpigmented and pink coloured; venter cream coloured (Fig. 4). One specimen was more thoroughly identified based on the following characters: 14 rows of smooth subequal scales, 323 mid-dorsals; 31 subcaudals; total length (119 mm)-tail (10 mm) ratio=11.9; subtriangular cloaca shield; rostral moderate, much wider than nasals dorsally, not reaching level of eyes; large ocular with small eye centrally placed in upper half and moderate posterior supralabial; frontal, supraoculars, and postfrontal subequal, forming a rather floral-like rosette pattern; temporal single (Broadley & van Wallach, 2007).

Figure 4. A specimen of *Myriopholis macrorhyncha* from Teddy Bear Island, Lake Baringo

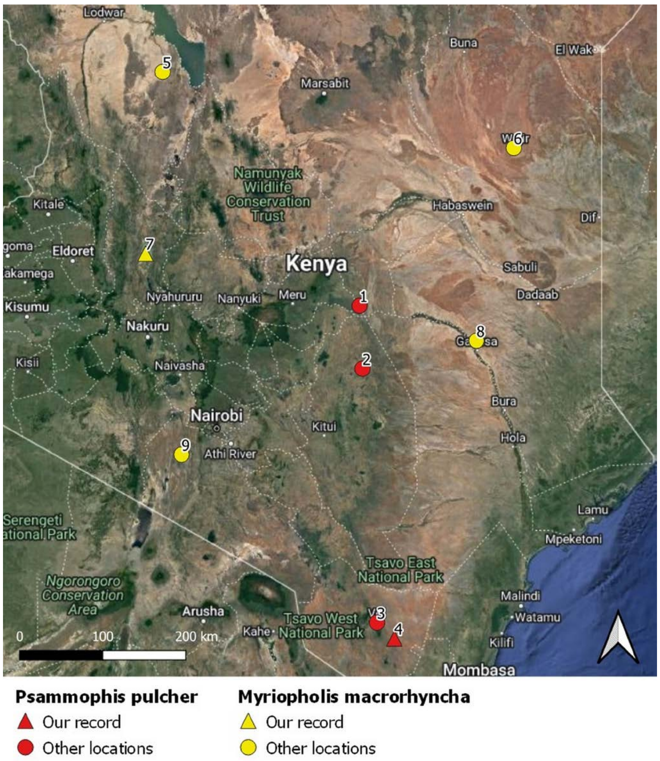

Figure 5. Old records of *Psammophis pulcher* and *Myriopholis macrorhyncha* in Kenya (Drewes & Spawls, 1973; Spawls et al., 2018; Malonza & Bwong, 2023), and the new records presented here: 1. Bisanadi NR, 2. Ngomeni, 3. Voi, 4. Maungu, 5. Lake Turkana, 6. Wajir, 7. Lake Baringo, 8. Sankuri and Garissa, 9. Olorgesailie

Myriopholis macrorhyncha has a wide distribution in north-east Africa and the Middle East (Uetz et al., 2023). This species is only sporadically recorded from Kenya and appears to have a patchy distribution in this country. It is known from Olorgesailie southwards to the Kilimanjaro and Mt. Meru (Tanzania), the area of Sankuri and Garissa, Wajir and the area of Lake Turkana (Spawls et al., 2018; Malonza & Bwong, 2023). Our records are the first from the Lake Baringo area, and represent a significant extension of the distribution range of this species, with the nearest known localities in the Lake Turkana area approximately 200 km northward (Fig. 5). Sympatric species of reptiles and amphibians that we recorded on Teddy Bear Island include *Crocodylus niloticus* Laurenti, 1768, *Dasypeltis scabra* (Linnaeus, 1758), *Hemidactylus angulatus* Hallowell, 1854, *Lygodactylus manni* Loveridge, 1928, *Naja pallida*, *Phrynobatrachus natalensis* (Smith, 1849), *T. quinquetaeniata* and *Varanus niloticus* (Linnaeus, 1766).

DISCUSSION

In this short note we have presented geographical range extensions for *P. pulcher* and *M. macrorhyncha*, comments on the ecology of *M. tornieri* and *H. pusillus* and observations of many sympatric species. Apart from South Africa, the herpetofauna of sub-saharan Africa is relatively poorly documented and observations such as these can make a significant contribution to faunal knowledge base, especially of the rarer species such as *P. pulcher*. Such data gathering should continue so that there is sound evidence of the establishment of conservation priorities and sufficient data to generate researchable hypotheses on the biogeography and ecology of these species.

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REFERENCES

AmphibiaWeb (2023). https://amphibiaweb.org. University of California, Berkeley, CA, USA. Accessed on 25 June 2023.

Babangenge, G.B., Jocqué, R., Masudi, F.M., Rödel, M.O., Burger, M., Gvoždík, V. & Pauwels, O.S. (2019). Frog-eating spiders in the Afrotropics: An analysis of published and new cases. *Chicago Herpetological Society* 54(3): 57–63.

Boulenger, G.A. (1895). An account of the reptiles and batrachians collected by Dr. A. Donaldson Smith in western Somaliland and the Galla Country. *Proceedings of the Zoological Society of London* 1895: 530–540.

Broadley, D.G. & Wallach, V. (2007). A revision of the genus *Leptotyphlops* in northeastern Africa and southwestern Arabia (Serpentes: Leptotyphlopidae). *Zootaxa* 1408: 1–78.

Channing, A. & Howell, K.M. (2006). Amphibians of East Africa. Frankfurt am Main: Chimaira Buchhandelgeselschaft mbH. 442 pp.

Channing, A. & Rödel, M-O. (2019). Field Guide to the Frogs & other Amphibians of Africa. Cape Town, Penguin Random House. 407 pp.

Drewes, R.C. & Spawls, S. (1973). The occurrence of the colubrid snake, *Psammophis pulcher*, in Kenya. *Herpetologica* 29: 306–307.

Loveridge, A. (1924). Checklist of the Reptilia recorded from the British territories in East Africa. *The Journal of the East Africa and Uganda Natural History Society*. Special Supplement No. 3: 1–18.

Malonza, P.K. (2003). Ecology and distribution of the pancake tortoise, *Malacochersus tornieri* in Kenya. *Journal of East African Natural History* 92: 81–96.

Malonza, P.K. & Bwong, B.A. (2023). A Field Guide to the Reptiles and Amphibians of Kenya. Frankfurt am Main: Chimaira Buchhandelgeselschaft mbH. 608 pp.

Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. & Kloepfer, D. (2004). Atlas and Red Data Book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB Series 9. Washington, DC: Smithsonian Institution. 360 pp.

Spawls, S. (1978). A checklist of the snakes of Kenya. *Journal of The East Africa Natural History Society and National Museum* 167: 1–18.

Spawls, S., Howell, K., Hinkel, H. & Menegon, M. (2018). Field Guide to East African Reptiles. London: Bloomsbury publishing. 624 pp.

Uetz, P., Freed, P., Aguilar, R., Reyes, F. & Hošek, J. (Eds.) (2023). The Reptile Database. http:///www.reptile-database.org. Accessed on 25 June 2023.

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SHORT COMMUNICATION

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Long-lasting asynchronous emergence of loggerhead sea turtle *Caretta caretta* in one of the northernmost nests on the Adriatic coast

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The loggerhead sea turtle *Caretta caretta* (L., 1758) is an endangered species distributed throughout subtropical and temperate regions. Due to menaces affecting its conservation status in the Mediterranean basin (Wallace et al., 2010), several conservation and management programmes have been established to protect and monitor its nesting sites (Casale, 2015).

In 2023, there were known to be 26 loggerhead sea turtle nests along the western coast of the Adriatic Sea. Most of these occurred in the Puglia region, except for two, which were located in the province of Teramo in Abruzzo and in the province of Ravenna in Emilia Romagna. The last two cases represent two of the most northern successfully hatched nests along the eastern Italian coast, together with Pesaro, Marche in 2019 (Mancino et al., 2022) and Jesolo, Veneto in 2021, which to date is the northernmost location recorded (Sénégas et al., 2009) (Fig. 1). Here I describe observations on a nest at the beach of the Borsacchio Nature Reserve in Teramo (Fig. 1). This is not the first occasion in which a sea turtle nest has been reported in the Abruzzo region, but it is the first time it has been possible to protect the nest site, thanks to the commitment of local associations. The importance of this case is not only linked to its geographical position but to the dynamics regarding hatching, which, in addition to occurring at the original site, represents a record for the longest-lasting asynchronous emergence of hatchlings from the nest.

Figure 1. The northern portion of the Adriatic Sea. Red dots correspond to the four most northern *Caretta caretta* nests recorded to date and successfully hatched.

On the afternoon of 18 July 2023, recent traces of a sea turtle nest were found along the beach of the Borsacchio Nature Reserve (Roseto degli Abruzzi, TE) at a distance of approximately 24.5 m above the mean low-water mark. Once the presence of the nest was verified, the site was immediately secured by volunteers from the associations Centro Studi Cetacei and Guide della Riserva Borsacchio. To protect the nest, seven days before the emergence of the hatchlings, the volunteers installed a circular fence of 1 cm mesh plastic net around it (4.4 m diameter and height of 0.50 m). With the same type of net they created a 1 m wide corridor towards the sea, crossing the beach perpendicularly finishing a few metres from the sea. The net encircling the nest could be opened where it joined the corridor, to allow access to the sea at times when hatchlings were emerging but was otherwise closed. Later, a second circular fence was installed around the nest but with a greater diameter (5.6 m) which allowed access to volunteers and experts but otherwise offered additional protection to the nest. The site was monitored 24 hours a day by volunteers and at night illuminated with low-impact red LED (RGB) lights with integral solar panels. The emergence of each turtle was monitored and assisted by volunteers from the associations, until they had entered several metres into the sea. Periodically, following the turtles' immersion, beach sections adjacent to the sea-entry corridor were checked in case the hatchlings had been dragged back onto the beach. Electronic probe thermometers (Arceli) were placed on the northern border of the net surrounding the nest with the probes penetrating the sand to a depth of 35 cm. An Aorlis electronic scale and a Zhjan digital calliper were used to collect morphometric data.

Figure 2. *Caretta caretta* hatchlings emerging from the nest site in the Borsacchio Nature Reserve in the province of Teramo, Abruzzo

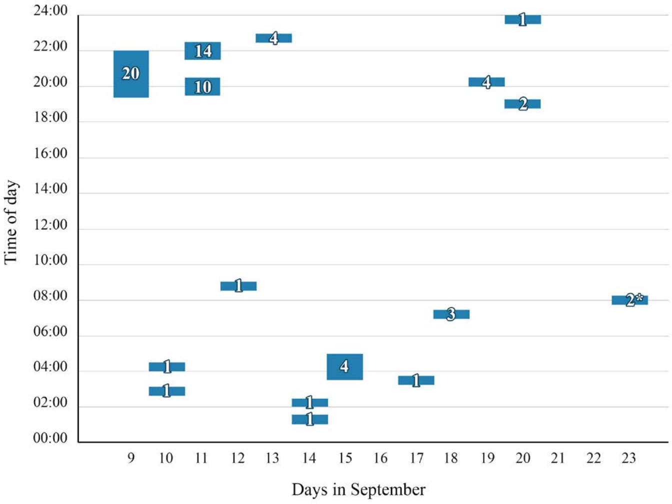

Figure 3. Date and time of day that hatchling *Caretta caretta* emerged from a nest in the Borsacchio Nature Reserve in the province of Teramo, Abruzzo. The bars represent time of hatchlings' activity (from emergence to immersion in the sea) and show the number of specimens. * Live specimens found during nest disinterring.

Since the nest was located within a nature reserve, it was free of bathing establishments in the nearby area, but was still frequented by residents and tourists. The area is almost completely natural, with the exception of a ruined building on the beach a few metres from the water, and a cycle path flanked by a railway parallel to the beach, located about 100–110 m from the sea. The beach consisted of fine white sand that was clean for about twenty metres from the sea. The closest sources of light pollution were located approximately 820 m north and 1,150 m south of the nest.

On the morning of 9 September, 53 days after the discovery of the nest, a depression formed in the centre of the nest at 07:30 h, which was a symptom of the imminent emergence of the hatchlings. The first specimens began to emerge twelve hours later, from 19:30 h to 22:00 h (Fig. 2), when 20 turtles found their way to the sea within two and a half hours. Two more specimens emerged during the night, before dawn. On the evening of 11 September, another 24 specimens emerged and headed towards the sea from 19:30 h to 22:14 h. In the following nine days, other specimens emerged individually or in small groups (max. 4) (Fig. 3).

The major activity of the hatchlings was observed from 18:45 h to 04:00 h, during twilight and night, while no activity was recorded from 09:00 h to 18:45 h (Fig. 3). The longest period of inactivity between emergences was 47 hours. Times from emergence to immersion in the sea (distance of about 24.5 m) varied from 20 to 45 minutes. The tracks left by the hatchlings on the sand provided evidence of the dispersal pattern within the delimited area circumscribing the nest. These were mainly orientated towards the south/south-east quadrant of the area. A few individuals 'inspected' the western portion of the fence, but none moved into the northern half, where the sand remained undisturbed.

On the morning of 23 September, 55 hours after the emergence of the last specimen, it was decided to disinter the nest due to an expected storm and the bad weather. In the egg chamber, which had a depth of 43 cm at the base, there were empty eggs shells, 12 infertile eggs, three dead hatchlings and two live hatchlings. Morphometric data of the last two specimens were taken before they were released. On average, they had a total length of 58 mm, carapace length of 40 mm, and weighed 15 g. The nest had contained a total of 84 eggs, from which a total of 70 hatchlings emerged, giving a hatch success rate of 86%. During the whole period of observation, the weather was almost continuously favourable. Strong winds never occurred and rain only fell on two occasions, both during the night. The temperature recorded by the electronic probes inserted into the subsoil showed no significant variations during the days when the nest was monitored, oscillating between 24.6 °C at night and a maximum of 25.7 °C during the day. The lowest temperature recorded was 24.2 °C during one of the two nights with rain.

Within the first three days of the emergence period two thirds of the hatchlings had left the nest, mostly in large groups, while the remaining third were distributed throughout the following days as single individuals or small groups consisting of a few individuals (Fig. 3). The incubation period of the eggs is not certain due to the wide spread of emergences from the nest but can at least be estimated roughly. It may be assumed that the nest was found on the morning after egg laying, we know that that the first hatchlings emerged 53 days later, that hatchlings are known to take from 2 to 7 days to reverse the folded posture assumed inside the egg, to absorb the yolk sac, and to dig themselves out of the nest (Godfrey & Mrosovsky, 1997; Miller et al., 2003). From this we can estimate that at least some of turtles hatched within about 46–51 days from egg laying. Most likely, the turtles did not all hatch at the same time, as 12 days elapsed between the first and last emergences from the nest, meaning that some of the hatchlings may have taken 14–19 days to emerge, while the last two specimens may have spent 17–22 days inside the egg chamber after hatching. As documented, in some nests around the Mediterranean basin, within-nest temperature differences can generate variations in the hatchlings' emergence patterns (Adam et al., 2007; Glen et al., 2005; Field et al., 2021).

The emergence of the hatchlings from the nest occurred over a period of 12 days (approximately 292 hours between the first and the last emergence), with the addition of two live specimens recovered on the morning of the 15th day (approximately 324.5 hours from the first emergence). This case represents one of, if not the longest, asynchronous emergences reported in the literature (Hays et al., 1992; Houghton & Hays, 2001; Adam et al., 2007). Although extended asynchronous emergence might seem disadvantageous in terms of natural selection, minor emergence groups have higher chances of surviving aquatic predation, as the number of hatchlings entering the water is lower (Wyneken et al., 1998; Pilcher et al., 2000; Glen et al., 2005).

A subject for future research would be the dispersal pattern and orientation of the hatchlings following emergence in the localities where nests of this species rarely occur. Since the nest site was delimited by a fence, the hatchlings were directed into a corridor that crossed the beach perpendicular to the sea. However, immediately after emergence the hatchlings were free to orientate around the nest area and there was a tendency for them to attempt to disperse more towards the south rather than the east (in the direction of the water). This could be an effect of light pollution or other variables (Witherington & Bjorndal, 1991).

Human activity in coastal zones has a significant impact on the reproduction of sea turtles. This study highlights the importance of nature reserves together with the work of associations and volunteers in the delivery of effective ecosystem conservation.

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REFERENCES

Adam, V., Tur, C., Rees, A.F. & Tomás, J. (2007). Emergence pattern of loggerhead turtle (*Caretta caretta*) hatchlings from Kyparissia Bay, Greece. *Marine Biology* 151: 1743–1749. Doi: 10.1007/s00227-007-0607-2.

Casale, P. (2015). *Caretta caretta* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2015: e.T83644804A83646294. Doi: 10.2305/IUCN.UK.2015-4.RLTS.T83644804A83646294.en.

Field, A., McGlashan, J.K. & Salomon, M. (2021). Evidence for synchronous hatching in marine turtle (*Caretta caretta*) embryos and its influence on the timing of nest emergence. *Chelonian Conservation and Biology* 20(2): 173–183. Doi: 10.2744/CCB-1489.1.

Glen, F., Broderick, A.C., Godley, B.J. & Hays, G.C. (2005). Patterns in the emergence of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtle hatchlings from their nests. *Marine Biology* 146: 1039–1049.

Godfrey, M.H. & Mrosovsky, N. (1997). Estimating the time between hatching of sea turtles and their emergence from the nest. *Chelonian Conservation and Biology* 2: 581–585.

Hays, G.C., Speakman, J.R. & Hayes, J.P. (1992). The pattern of emergence by loggerhead turtle (*Caretta caretta*) hatchlings on Cephalonia, Greece. *Herpetologica* 48(4): 396–401.

Houghton, J.D.R. & Hays, G.C. (2001). Asynchronous emergence by loggerhead turtle (*Caretta caretta*) hatchlings. *Naturwissenschaften* (2001)88: 133–136. Doi: 10.1007/s001140100212.

Mancino, C., Canestrelli, D. & Maiorano, L. (2022). Going west: Range expansion for loggerhead sea turtles in the Mediterranean Sea under climate change. *Global Ecology and Conservation* 38: eo2264.

Miller, J.D., Limpus, C.J. & Godfrey, M.H. (2003). Nest site selection, oviposition, eggs, development, hatching, and emergence of loggerhead turtles. In *Loggerhead Sea Turtles*. 125–143 pp. Bolton, A.B. & Witherington, B.E. (Eds.). Washington, DC: Smithsonian Institution Press.

Pilcher, N.J., Enderby, S., Stringell, T. & Bateman, L. (2000). Nearshore turtle hatchling distribution and predation in Sabah, Malaysia. In *Proceedings of the 19th annual symposium on sea turtle conservation and biology*. 27–29 pp. Kalb, H. & Wibbels, T. (Eds.). NOAA technical memorandum NMFS 443.

Sénégas, J-B., Hochscheid, S., Groul J-M., Lagarrigue, B. & Bentivegna, F. (2009). Discovery of the northernmost loggerhead sea turtle (*Caretta caretta*) nest. *Marine Biodiversity Records* 2009: 2:e81. Doi: 10.1017/S1755267209000773.

Wallace, B.P., DiMatteo, A.D., Hurley, B.J., Finkbeiner, E.M., Bolten, A.B., Chaloupka, M.Y. et al. (2010). Regional management units for marine turtles: A novel framework for prioritizing conservation and research across multiple scales. *PLoS ONE* 5(12): e15465. Doi: 10.1371/journal.pone.0015465.

Witherington, B.E & Bjorndal K.A. (1991). Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. *Biological Conservation* 55(2): 139–149.

Wyneken, J., De Carlo, L., Glenn, L., Salmon, M., Davidson, D., Weege, S. & Fisher, L. (1998). On the consequences of timing, location and fish for hatchlings leaving open beach hatcheries. In *Proceedings of the 16th annual symposium on sea turtle biology and conservation*. 155–156 pp. Byles, R. & Fernandez, Y. (Eds.). NOAA technical memorandum NMFS 412.

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Courtship and mating behaviour of the intermediate bow-fingered gecko *Cyrtodactylus intermedius* in the wild

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The semi-arboreal gecko, *Cyrtodactylus intermedius* (Smith, 1917), endemic to south-east Asia, was first described from Khao Sebab Mountain in Chantaburi Province, south-east Thailand. The geographic range of the species includes Khao Sebab Mountain (in the Cardamom Mountains) and the Dong Phaya Yen-Khao Yai forest complex of Thailand, Phnom Aural Wildlife Sanctuary and the Cardamom Mountains of Cambodia, and throughout the Dong Nai and Kien Giang Provinces of Vietnam. This species is also found in the dry evergreen forest of the Sakaerat Biosphere Reserve (SBR) which is part of the Dong Phaya Yen-Khao Yai forest complex in north-eastern Thailand. We report here the first observation of the courtship and mating behaviour of *C. intermedius* in the SBR.

On 2 July 2020, in the middle of the rainy season, during a herpetological night survey in the dry evergreen forest of the SBR, we observed and photographed the courtship and mating of a pair of *C. Intermedius*. This occurred on a natural trail (14° 29’59.4708’’ N, 101° 55’35.1084’’ E, 496 m a.s.l.). The geckos were positioned approximately 30 cm up the dead trunk of a native spiny shrub tree (*Streblus ilicifolius*). The female gecko was clearly larger than the male and the species identified later when a hemipene was visible from the male. We witnessed courtship and mating behaviours from 19:46 h to 20:32 h in the drizzling rain, following heavy rain in the late afternoon. Temperature and humidity were 28 °C and 84% respectively according to the SBR weather station in the dry evergreen forest.

The courtship period (19:46 to 20:24 h)

The male was initially observed clinging to the back of the female in a vertical position. He then twisted the posterior portion of his body, on the left-hand side of the female, and put his tail under her cloaca. He was flicking his tail, possibly to stimulate the female (Fig. 1A). Eight minutes later (19:54 h), the male moved the anterior portion of his body onto her back and waited for her to accept his advances (Fig. 1B). The mating did not occur and the female began to move around (Fig. 1C). The male then pressed his head against the middle of her dorsum. At 20:22 h, the female moved closer to the ground with her head down and tail stiff. The male pressed his weight on her back, and his right fingers pushed her head, appearing to control her motions. The male’s cloaca was bulging at this time and turned a bloody-reddish colour (Fig. 1D). The pair finally rotated back into an upright position, with the male completely clinging to her back (Fig. 1E). Then the male inserted his tail base, causing the female to lift her tail (Fig. 1F).

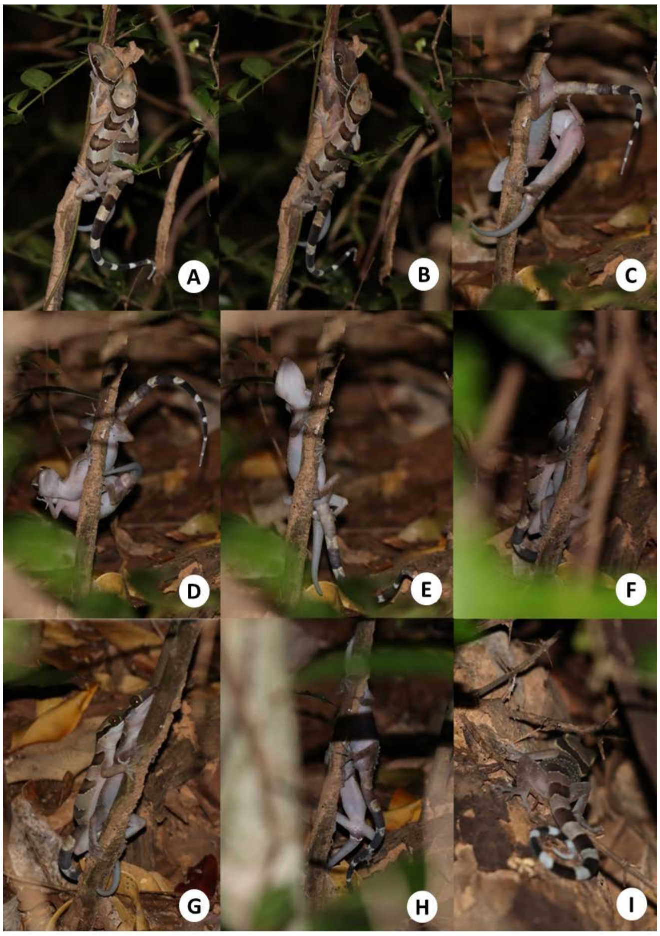

Figure 1. Mating activity of *Cyrtodactylus intermedius* - **A.**–**F.** Courtship from 19:46–20:24 h, **G.**–**H.** mating from 20:24–20:28 h, and **I.** after mating from 20:28–20.32 h

The mating period (20:24 to 20:28 h)

The male pressed his body tightly downwards on the female using the front limbs on the tree trunk. He finally inserted a hemipene into her cloaca (Fig. 1G). The hemipene was inserted for four minutes before being pulled out (Fig. 1H).

The after-mating period (20:28 to 20:32 h)

The gecko pair eventually separated after mating (Fig. 1I). The observed sequence terminated when the two lizards disappeared from view.

Mating behaviours of *Cyrtodactylus* geckos have been little documented. The only one observed previously in the wild was *Cyrtodactylus macrotuberculatus* (Quah et al., 2022). They mate in an upright posture in the middle of the monsoon season, which corresponds to this observation of *C. intermedius*. At SBR, the seasonal breeding period of *Cyrtodactylus* spp likely varies according to species (Artchawakom & Suttanon, undated). In the cases of *Cyrtodactylus quadrivirgatus* and *Cyrtodactylus seribuatensis* there appears to be an extended reproductive cycle (Goldberg & Grismer, 2015; 2016) and in the cases of *C. macrotuberculatus* and *Cyrtodactylus phuketensis* they are known to mate throughout the year (Quah et al., 2022; Sumontha et al., 2012; Termprayoon et al., 2021). We observed *C. intermedius* mating in July and there is also a record of *C. intermedius* mating in Khao Yai National Park, north-eastern Thailand, in early July which is in the middle of the rainy season (Panitvong et al., 2012). Other observations on reproductive activity of *C. intermedius* at SBR include a gravid female that was carrying two eggs in November through February, and juveniles presented in January. It seems possible that *C. intermedius* has a limited reproductive period initiated during the rainy season but further research is required to confirm this.

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REFERENCES

Artchawakom, T. & Suttanon, N. (undated). Diversity of Reptiles in Sakaerat Environmental Research Station. Sakaerat Environmental Research Station. https://www.tistr.or.th/sakaerat/Flora_Fauna/REPTILE/REPTILE.HTM.

Goldberg, S.R. & Grismer, L.L (2015). *Cyrtodactylus seribuatensis* (Seribuat Bent-Toed Gecko). Reproduction. *Herpetological Review* 46: 89–90.

Goldberg, S.R. & Grismer, L.L. (2016). *Cyrtodactylus quadrivirgatus* (Four-striped Forest Gecko) Reproduction. *Herpetological Review* 47(4): 667–668.

Panitvong, N., Lauhachinda, V., Saithong, S. & Temchai, T. (2012). Ecology of *Cyrtodactylus sumonthai* Bauer, Pauwels & Chanhome, 2002 (Reptilia: Squamata: Gekkonidae): a karst dwelling bent-toed gecko from south-eastern Thailand. *Raffles Bulletin of Zoology* 60: 569–582.

Quah, E.S.H., Grismer, L.L. & Shahrul, A.M.S. (2022). Observation of *Cyrtodactylus macrotuberculatus* Grismer & Norhayati 2008 (Squamata, Gekkonidae) mating behavior in the wild. *Herpetology Notes* 15: 291–294.

Sumontha, M., Pauwels, O.S., Kunya, K., Nitikul, A., Samphanthamit, P. & Grismer, L.L. (2012). A new forest-dwelling gecko from Phuket Island, Southern Thailand, related to *Cyrtodactylus macrotuberculatus* (Squamata: Gekkonidae). *Zootaxa* 3522: 61–72.

Termprayoon, K., Rujirawan, A., Grismer, L.L., Wood, P.L. & Aowphol, A. (2021). Taxonomic reassessment and phylogenetic placement of *Cyrtodactylus phuketensis* (Reptilia, Gekkonidae) based on morphological and molecular evidence. *ZooKeys* 1040: 91–121.

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SHORT COMMUNICATION

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Attempted predation by *Coronella austriaca* on grass snakes *Natrix natrix* and an adult northern viper *Vipera berus* in Norway

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The smooth snake *Coronella austriaca*, grass snake *Natrix natrix* and northern viper *Vipera berus* are sympatric in Norway, the smooth snake being the only reptile species on the national red list categorised as Near Threatened (NT). All three snake species are widely distributed in Europe (Speybroeck et al., 2016). In Norway specifically, the grass snake and the smooth snake have similar ranges along the coast surrounding the outer Oslo fjord, from the border with Sweden in the south-east to Stavanger in the south-west, extending northwards to 60° latitude, while the more cold-tolerant northern viper is found from the coast to 1000 m above sea level in the mountains and to almost 72° N. All three snake species are found together in the same locations along the southern coast in Norway, though the northern vipers tend to avoid the microhabitats that are used intensively by smooth snakes (author’s observations). This negative correlation in habitat use has also been noted in England (Phelps, 1978). Smooth snakes and grass snakes, however, often bask and shed in exactly the same locations in the author’s long term study area of Kristiansand, southern Norway.

There are well known examples of snakes with a specialised dietary preference for other snakes (ophiophagy), such as King cobras *Ophiophagus hannah*, whose generic name derives from its dietary habits, kraits (*Bungarus* spp) and file snakes (*Mehyla* spp). In Europe, there are no snake species that specialise in ophiophagy but the smooth snake is a well-known reptile predator feeding mainly on lizard species and small mammals across its European range (Beebee & Griffiths, 2000) but has on occasion been recorded eating snakes. The NCC-Report (1983) referenced in Beebee and Griffiths (2000) refers to 6% of the smooth snake diet in England being made up of immature and juvenile northern vipers, 4% being immature and juvenile smooth snakes and 2% adult grass snakes as determined by analysis of regurgitates and faecal material. The current article describes direct observations of three adult smooth snakes attempting to eat grass snakes and a northern viper.

As part of an ongoing long term smooth snake monitoring and research project, an old military area from the second world war is visited regularly (Møvik, Kristiansand, 58° 5’33.26829” N, 7° 58’10.47294” E). On 28 September 2023 at 15:17 h the author discovered a smooth snake that was constricting a very small snake that was identified as a hatchling grass snake (Fig. 1). This was released when the smooth snake became aware of the observer. At first sight it appeared that the hatchling was dead, and blood was visible around its mouth. Both individuals were weighed and measured. The smooth snake was a known female that had bred the previous year and was non-breeding that year in preparation for breeding the following year, which is typical of the species in Norway. She weighed 96 g with a snout vent length (SVL) of 59.5 cm and total length of 70 cm. She had last been recorded feeding on a slow-worm *Anguis fragilis* on 20 July 2023. The grass snake weighed 3 g with an SVL

Figure 1. Adult smooth snake *Coronella austriaca* constricting a neonate grass snake *Natrix natrix* on 28 September 2023 in Kristiansand, southern Norway

Figure 2. Hatchling grass snake Natrix natrix having been constricted by an adult smooth snake Coronella austriaca. The individual is in the last stage of sloughing, 28 September 2023 in Kristiansand, southern Norway.

Figure 3. An adult female smooth snake consuming a grass snake in Kristiansand, southern Norway in May 2024

of 16.7 cm and a total length of 20.5 cm and was sloughing (Fig. 2). Despite signs of injury the grass snake appeared to make a full recovery and it was released where it was found.

A second, but more successful, predation attempt on a grass snake by a smooth snake was observed on 3 May 2024 at 10:00 h in Kristiansand. The smooth snake was of adult size with typical female colouration, lacking orange pigment on the sides of the head. When the smooth snake was first observed, most of the grass snake was already eaten (Fig. 3). The observation was made in a south facing location by a lake with lots of sunshine early in the day; the site is frequented by shedding grass snakes and smooth snakes and by gravid smooth snakes.

A third and rather different example was of a smooth snake on 19 May 2023 in the forest of Mykland in the Agder county in southern Norway (58° 36′16.75836″ N, 8° 16′47.87438″ E). A forest walker observed two entwined snakes fully exposed on a sandy track in sunny conditions with an air temperature of between 18–20 °C. Upon inspection the snakes were found to be an adult smooth snake and an adult melanistic northern viper. The latter was in the early stages of being eaten by the smooth snake when found (Fig. 4). Regrettably the walker left the snakes and continued with his walk and upon his return both snakes had gone. It is not known therefore whether the smooth snake completed its predation on the viper nor indeed whether the viper had been killed by the snake or was already dead when it was found by the smooth snake.

Figure 4. Adult smooth snake *Coronella austriaca* has started to ingest an adult northern viper *Vipera berus* in Mykland, inland Agder county, southern Norway on 19 May 2023

In the first example of grass snake predation described above, three further hatchling grass snakes were found within two metres suggesting that the smooth snake could have enjoyed a substantial meal prior to hibernation. It is possible that smooth snakes deliberately target grass snake egg laying sites, as in Poland two juvenile *N. natrix* were found in the stomach of a dead adult female smooth snake (Najbar, 2001); and it was suggested that adult smooth snakes actively seek out egg-laying locations of grass snakes, and subsequently eat the neonate snakes on emergence. However, in the case described here the egg laying site was known to be within this smooth snake's home range and also that of four or five other smooth snakes. The constriction of such a small prey item was probably unnecessary but such behaviour was likely to have been instinctive. Pål Sørensen reports from smooth snakes in terraria during the 1970's that one adult female ingested another slightly smaller female, and a juvenile swallowed a sibling with the result that both siblings died. Also, a juvenile smooth snake swallowed a juvenile American corn snake *Pantherophis guttatus*. Interestingly all three victims were sloughing, as was the constricted neonate grass snake reported here. Also, Kolanek & Bury (2020) observed that a juvenile smooth snake attempted cannibalism of a sibling just after their first shed and suggested that the shed may have triggered this behaviour. A Norwegian Lundehund (small dog) trained for finding smooth snakes in eastern Norway finds clutches of newborn smooth snakes during their first slough that are not visible to us and detect sloughs that are hidden under vegetation (Rune Botnermyr, pers comm). It is highly likely that this dog detects these neonates and sloughs by olfaction. Larger smooth snakes that are not sloughing are not detected by the dog unless they move, leading to visual detection. Andrén (1986) makes it clear that male adders only respond to each other in springtime once they have moulted (sloughed) and in the presence of a reproductive female. Incidentally, various studies note that some bird species, for example black-capped donacobius (*Donacobius atricapilla*), use sloughs to deter mammal predators from their nests (Almeida et al., 2014).

It would be of interest to undertake further research into Norway's rarest snake to determine the proportion of snakes in its diet, whether it may reduce northern viper populations in its strongholds, and if it seeks out grass snake egg-laying sites to prey on hatchlings. Finally, investigation of whether the odour released from a sloughing snake is a behavioural cue in ophiophagy would be help to explain our observations.

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REFERENCES

Almeida, S.M., Strüssmann, C. & Evandson Anjos-Silva, J. (2014). Snake's exuviae as habitual nesting material of the Black-capped Donacobius (*Donacobius atricapilla*) (Passeriformes: Donacobiidae) in the Pantanal Wetlands. *Ornitologia Neotropical* 25: 47–53.

Andrén, C. (1986). Courtship, mating and agonistic behaviour in a free-living population of adders, *Vipera berus* (L.). *Amphibia-Reptilia* 7: 353–383.

Beebee, T.J.C. & Griffiths, R.A. (2000). Amphibians and Reptiles. A Natural History of the British Herpetofauna. London: Harper Collins. 270 pp.

Kolanek, A. & Bury, S. (2020). *Coronella austriaca* (smooth snake): Diet/Cannabalism. *Herpetological Review* 51(3): 612.

Najbar, B. (2001). The diet of *Coronella austriaca* Laur., 1768 in the Lubuskie region (western Poland). *Bulletin of the Polish Academy of Sciences Biological Sciences* 49(1): 33–39.

NCC-REPORT (1983). The ecology and conservation of amphibian reptile species endangered in Britain. London (Nature Conservancy Council). 93 pp.

Phelps, T. (1978). Seasonal movement of the snakes *Coronella austriaca, Vipera berus, Natrix* in southern England. *British Journal of Herpetology* 5: 755–761.

Speybroeck, J., Beukema, W., Bok, B. & Van Der Voort, J. (2016). Field Guide to the Amphibians & Reptiles of Britain and Europe. London, United Kingdom: Bloomsbury Publishing Plc. 432 pp.

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SHORT COMMUNICATION

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New record of the keelback *Rhabdophis leonardi* in Manipur with a discussion of the status of the species in India

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One of the neglected species of Indian herpetofauna is *Rhabdophis leonardi*. It was not included in the 2018 Checklist of Reptiles in India published by the Zoological Survey of India (Aengals et al., 2018), and India is not listed within the range of *R. leonardi* in the Reptile Database (Uetz et al., 2024a). Several recent papers on *R. leonardi* restrict its discussed range to southwest China and adjacent Myanmar (Zhu et al., 2022; Yang et al., 2023). However, the presence of *R. leonardi* in India has been established by Nguyen & David (2023), they found that snakes from Nagaland initially identified as *Rhabdophis nuchalis* in fact fit the description of *R. leonardi*, and proposed that only *R. leonardi*, not *R. nuchalis*, should be considered a resident Indian snake. Their finding suggests that researchers may have sighted *R. leonardi* elsewhere in India but misidentified it.

From 23 to 26 April 2023, the author undertook an informal walking survey of the roads in and around Phuba Thapham, Senapati District, Manipur. This village, situated 27 km north-east of the district headquarters in Senapati, is surrounded primarily by rice paddies, further enveloped by community forest lands from which most of the primary forest has been logged. Due in part to the remote location of the village and limited development of the roads in the region, no previous reptile research is known to have been undertaken in the region. Further details on the limited history of reptile research in Manipur can be found in Hakim (2023).

At 09:32 h on 26 April 2023, the author and his companions encountered a dead juvenile *Rhabdophis* on an unpaved road uphill from Phuba Thapham at 25° 23’27.54’’ N, 94° 15’33.66’’ E, at an altitude 1845 m. The area in which the snake was found is a border zone between rice paddies and heavily disturbed forest. The snake (Fig. 1) superficially appeared to be a match for *Rhabdophis himalayanus*, a slender greyish keelback with a thin orange-yellow collar. However, Xiong Feng Li (pers. comm.) noted upon viewing the photos that the specimen had 6 supralabials and 7 infralabials, placing it into the *R. leonardi/nuchalis* species complex rather than *R. himalayanus/Rhabdophis bindi*, which have 8 supralabials and 10–11 infralabials.

Further analysis of the voucher photographs demonstrated that this specimen matches the diagnostics for *R. leonardi* (Nguyen & David, 2023) in having 6 supralabials, 3rd and 4th in contact with the eye, with an oblique black band across the suture between 4th and 5th supralabials; 7/8 infralabials, first 4 in contact with anterior chinshields and 4th to 6th in contact with posterior chinshields; 2 supranasals; 2 prefrontals; 1 frontal; 2 parietal; loreal present; 1 preocular; 1 superocular; 3 postoculars (1 is very small); 1+2 temporals, and nuchal gland present. The ventral count is 149 and the subcaudal count is 49, though there is slight uncertainty on the ventral count due to damage to the scales. This damage also precluded an exact scale row count on most of the body. Nonetheless, at approximately the 70th ventral, a complete count could be made of 16 scales in five consecutive rows (Fig. 1D), in line with the reduction from 17 to 15 that occurs in *R. leonardi* near midbody.

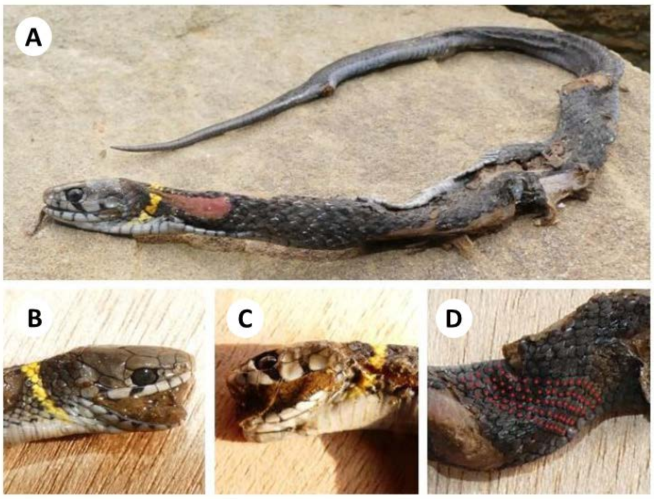

Figure 1. Juvenile *Rhabdophis leonardi* [ZRC(IMG) 2.674a-h] found in Phuba Thapham, Manipur, India - **A.** Full body view, **B.** Right dorsolateral view of head, **C.** Left lateral view of head, **D.** Scale count just short of midbody showing 16 rows

These attributes key the snake out to *R. leonardi* according to the chart of *Rhabophis* keelbacks found in Yang et al. (2023). The presence of 16 scales near the midbody rules out its closest relative, *R. nuchalis*, which consistently displays 15 scale rows throughout its length. Furthermore, *R. nuchalis* can be ruled out by the range established in Zhu et al. (2022), which restricts *R. nuchalis* senso stricto to no closer than Tangjiahe, Sichuan, China, 1,140 km north-east of our locality (Nguyen & David, 2023). The only other species listed in the Yang et al. (2023) key that may display 16 scale rows at or before midbody is *Rhabdophis angeli*, which occasionally starts with 16 scale rows before reducing to 15, but this species has a much lower ventral count (117–126) and subcaudal count (39–46), furthermore it is restricted to a small range in Vietnam, 1,236 km south-east of our specimen's locality. A recently described species not present in the Yang et al. (2023) key, *Rhabdophis kaiyuanensis*, also sometimes reduces through 16 scale rows near the midbody (Liu et al., 2023), but the diagnostic of *R. kaiyuanensis* differs from our specimen in lacking a bright collar on the neck, lacking dark bands on the supralabials, and having a range currently restricted to Kaiyuan, Yunnan Province, China, which is 943 km east of our specimen location.

The identification of our specimen as *R. leonardi* was confirmed by Patrick David and by Guang-Xiang Zhu after an examination of pattern and scalation. This represents the first record of *R. leonardi* in Manipur, 35 km south-east of the nearest previous records in Khonoma, Nagaland (Ahmed & Das, 2006; Nguyen & David, 2023). Photographs of the specimen were deposited as photo vouchers in the Lee Kong Chian Natural History Museum in Singapore [ZRC(IMG) 2.674a-h].

Patrick David noted that our specimen differs from most recorded *R. leonardi* in having a thin yellow collar, rather than the published diagnostic of a thin orange collar in females. However, the juvenile snake from Ahmed & Das (2006) that was identified as *R. leonardi* by Nguyen & David (2023) also shows a yellow collar similar in tone to our specimen [see the photo in Uetz et al. (2024b)], as does the genetically confirmed hatchling *R. leonardi* from Xiaoshanbao Village in South Sichuan Province, China, which is photographed on page 11 of Yang et al. (2022).

With the confirmation of *R. leonardi* in Nagaland and Manipur, the species is likely present elsewhere in north-east India. A road-damaged snake in Arunachal Pradesh posted by Ronith Urs on iNaturalist on 3 July 2023 (https://www.inaturalist.org/observations/170850200) appears to be morphologically similar to *R. leonardi*, though the degree of damage to the specimen precludes identification via scale counts. Attention should be given to future *Rhabdophis* specimens in other north-east Indian states as well as Myanmar, Bhutan, Nepal and Tibet to ensure that *R. leonardi* finds are not accidentally misidentified as *R. himalayanus* or *R. nuchalis*.

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REFERENCES

Aengals, R., Kumar, V.M.S., Palot, M.J. & Ganesh, S.R. (2018). A Checklist of Reptiles of India (v. 3). Kolkata: Zoological Survey of India. 35 pp.

Ahmed, M.F. & Das, A. (2006). First record of *Rhabdophis nuchalis* (Boulenger, 1891) (Serpentes: Colubridae) from India, with notes on its distribution and natural history. *Hamadryad* 30(1 & 2): 120–126.

Hakim, J. (2023). New distribution record of the Chin Hills Keelback, *Hebius venningi* (Wall 1910) (Natricidae), from Manipur, Northeast India. *Reptiles & Amphibians* 30(1): e20402.

Liu, Q., Lyu, B., Xie, X., Zeng, Y. & Guo, P. (2023). Genomic evidence sheds new light on phylogeny of *Rhabdophis nuchalis* (sensu lato) complex (Serpentes: Natricidae). *Molecular Phylogenetics and Evolution* 189: 107893.

Nguyen, T.V. & David, P. (2023). On the occurrence of *Rhabdophis leonardi* (Wall, 1923) in Vietnam and Laos, with preliminary comments on the taxonomy and distribution of the complex of *Rhabdophis nuchalis* (Squamata: Sepentes: Natricidae). *Russian Journal of Herpetology* 30(4): 224–236.

Uetz, P., Freed, P. & Hošek, J. (2024a). *Rhabdophis leonardi.* The Reptile Database. http://www.reptile-database.org. Accessed on 18 February 2024.

Uetz, P., Freed, P. & Hošek, J. (2024b). *Rhabdophis nuchalis.* The Reptile Database. http://www.reptile-database.org. Accessed on 18 February 2024.

Yang, S.J., Savitzky, A.H., Gower, D.J., Deepak, V., Mori, A. et al. (2023). Identity of the holotype and type locality of *Rhabdophis leonardi* (Wall, 1923)(Colubridae: Natricinae), with notes on the morphology and natural history of the species in southwestern China. *Ecology and Evolution* 13(5): e10032.

Zhu, G.X., Wang, Y.Y., Hirohiko, T. & Zhao, E.M. (2014). A new species of the genus *Rhabdophis* Fitzinger, 1843 (Squamata: Colubridae) from Guangdong Province, southern China. *Zootaxa* 3765(5): 469–480.

Zhu, G.X., Yang, S., Havitzky, A.H., Cheng, Y., Mori, A. et al. (2022). Cryptic diversity and phylogeography of the *Rhabdophis nuchalis* group (Squamata: Colubridae). *Molecular Phylogenetics and Evolution* 166: 107325.

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Do juvenile four-lined snakes *Elaphe quatuorlineata* mimic their sympatric viper?

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In Batesian mimicry, harmless species gain protection from predators by mimicking the warning signals of sympatric species that are more dangerous or venomous than themselves (Ruxton et al., 2004). This mimicry is well documented among many different groups of animals, including snakes (Brodie & Brodie, 2004), and may include aspects of morphology, behaviour, secretions or even sounds (Caro, 2014). In the case of the rat snake genus *Elaphe*, both adult and juvenile individuals of at least two species are known to mimic viper species; *Elaphe davidi* mimics the colouration and head shape of *Gloydius* spp., and *Elaphe xiphodonta* is proposed as a mimic of the pitviper, *Protobothrops jerdonii* in body shape, colouration and pattern and even cloacal gland odour (Qi et al., 2021). Among the European *Elaphe* spp, none has yet been proposed as a potential viper mimic.

In this note, we describe a case of a juvenile four-lined snake, *Elaphe quatuorlineata* (Lacépède, 1789) displaying bluffing behaviour. Besides providing a description of the context which elicited the behaviour, we argue that this could be a case of Batesian mimicry between juvenile *E. quatuorlineata* and the sympatric nose-horned viper, *Vipera ammodytes meridionalis* (Boulenger, 1903) due to the close geographical association between these species, similar colour pattern and defensive behaviours.

Elaphe quatuorlineata is a large and robust snake, inhabiting humid and densely vegetated Mediterranean habitats (Speybroeck et al., 2016). Adults of this species are usually grey, olive, or beige, often darker on the back with paired black lines running along each flank. In stark contrast, juveniles display a distinct pattern, featuring dark, black-bordered irregular patches on the back and a row of black blotches on each flank, typically with a more greyish hue than the adult colour (Fig. 1A). From morpho-ecological (Cattaneo & Grano, 2012) and molecular studies (Kornilios et al., 2014; Thanou et al., 2020), it appears that the nominotypical subspecies inhabits the study area. *Elaphe quatuorlineata* is generally characterised as a docile snake, rarely biting when handled and usually resorting to hissing and tail displays to distract predators when threatened (Böhme & Ščerbak, 1993; Schulz, 1996; Valakos et al., 2008; Speybroeck et al., 2016). However, these observations are likely drawn from adult snakes, as juvenile defence behaviours tend to be overlooked. A previous study that used machine deep-learning to uncover potential cases of mimicry between non-venomous and venomous Western Palearctic snakes, failed to identify *E. quatuorlineata* as a potential mimetic species (de Solan et al., 2020) probably because only adult, rather than juvenile colouration, was considered.

On 14 April 2023, 14:17 h EEST, a juvenile of *E. quatuorlineata* was observed swimming in the shallow waters of the Messapios River, a torrent located in central Euboea (Evia) Island, Greece. Around the riverbed, there

Figure 1. Comparison between the recorded individual four-lined snake *Elaphe quatuorlineata* and a sympatric viper - **A.** Juvenile *Elaphe quatuorlineata* swimming in the shallow waters of Messapios River, central Euboea, Greece, **B.** Male nose-horned viper *Vipera ammodytes meridionalis* from central Euboea

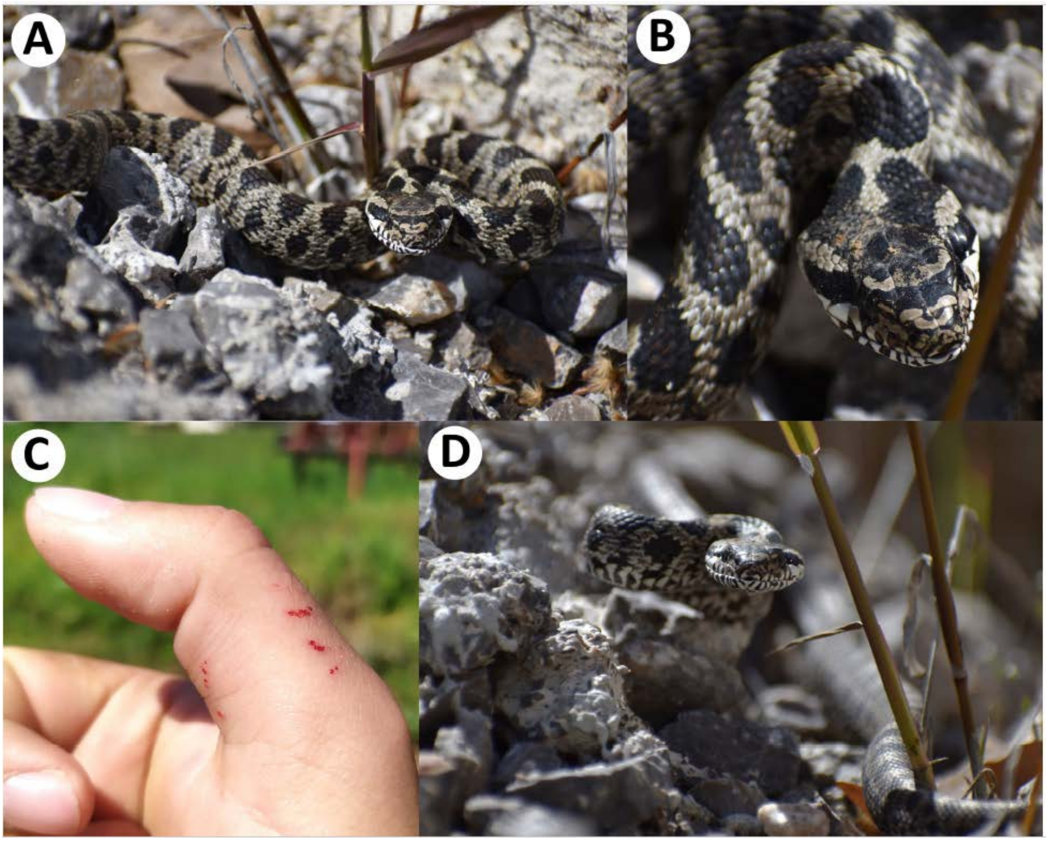

Figure 2. Viper-like behaviour of a juvenile four-lined snake, *Elaphe quatuorlineata* - **A.** Defensive body posture, **B.** Flattened triangular head, **C.** Wounds caused by the bite, **D.** Raised, flattened triangular head

were a variety of habitats, including plane trees, macchia, fields for agriculture, olive groves and urban habitats. *Elaphe quatuorlineata* seemed to be the most common snake in the area living in sympatry with *V. ammodytes*, the eastern Montpellier snake *Malpolon insignitus*, the grass snake *Natrix natrix*, the leopard snake *Zamenis situla*, the Balkan whip snake *Hierophis gemonensis* and Dahl's whip snake *Platyceps najadum* (Valakos et al., 2008; pers. obs.). The *E. quatuorlineata* was easily identifiable due to its distinct colouration, which also served to determine the sexual maturity (Fig. 1A). The snake, upon spotting the first author (FA), left the water trying to hide between the rocks of the bank. Failing to find an adequate hiding place and with FA still approaching, the snake assumed a defensive stance, raising the forebody and flattening the head giving it a more triangular appearance (Fig. 2A & B). The individual also bit FA when he was in close proximity to the snake taking photographs (Fig. 2C), although no effects of the bite were experienced thereafter. When FA retreated from the snake, it started to flee but was still maintaining a defensive posture, keeping the flattened triangular head raised (Fig. 2D). When the snake found a hole among the rocks, it hid immediately.

In this case, the juvenile *E. quatuorlineata* exhibited defence behaviours commonly used by European vipers. Head flattening behaviour is common among snakes and has been proposed as an important warning signal against avian predators (Valkonen et al., 2011, Dell'Aglio et al., 2012), which in combination with zigzag patterns seemingly reduce successful predator attacks (Niskanen & Mappes, 2005; Guimarães & Sawaya, 2011). Head flattening is regularly considered as mimicry when displayed by non-venomous snakes. A good example is the species of the genus *Natrix* which often show increased head flattening, and other bluffing behaviours, when living in close proximity with vipers (Kabisch, 1974; Brodie & Brodie, 2004; Tuniyev et al., 2011; Valkonen et al., 2011; Bjelica et al., 2023). This viper-like behaviour can not only mislead predators but even humans (Hayakawa et al., 2011; Valkonen et al., 2018; Frynta et al., 2023). Head flattening has only previously been mentioned for *E. quatuorlineata* by Schulz (1996), but at that time the taxonomic status of the species was still under investigation, while Böhme & Ščerbak (1993) specify this defensive behaviour only for the blotched snake, the former subspecies *E. q. sauromates* and now currently the full species *Elaphe sauromates*.

Besides defence behaviour, the juvenile colour pattern of *E. quatuorlineata* at this locality bears some resemblance to those typical of vipers (Valakos et al., 2008), consequently we suggest that both behaviour and colour pattern both contribute to Batesian mimicry. However, the possibility remains that the colour pattern of juvenile of *E. quatuorlineata* is simply convergent evolution of disruptive colouration to help hide the snake.

It is noteworthy that *E. quatrolineata* undergoes a drastic change in colour when reaching adult size. What is also interesting it that it adopts a significantly different approach to its defence against predators, resorting to flight and hissing. Smaller individuals are likely under greater predation pressure (Bonnet et al., 2005; Gray, 2015; Bjelica et al., 2023) and so may have to have evolved bluffing displays to increase their chances of survival. It would be of interest to use *E. quatrolineata* as a model for exploring ontogenetic shifts in colour and defence behaviour. Future studies should also test the variety of defensive responses in four-lined snakes and examine the factors that may affect them, especially age, body size and colour pattern. As far as confirming the hypothesis that juvenile *E. quatuorlineata* are viper mimics, an interesting future study would be a comparative analysis of the defence responses in juvenile individuals of different *E. quatuorlineata* subspecies — *E. q. quatuorlineata* (Lacépède, 1789), *E. q. muenteri* (Bedriaga, 1882) *E. q. scyrensis* (Cattaneo, 1999) and *E. q. parensis* (Cattaneo, 1999). All of the subspecies, save *E. q. scyrensis* (no vipers in Skyros Island; Cattaneo, 1998) are widely sympatric with *V. ammodytes*, and thus should be more 'viper-like' in appearance and behaviour than *E. q. scyrensis*.

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REFERENCES

Aloise, G., Mazzei, A. & Brandmayr, P. (2010). An attempted predation on a four-lined snake *Elaphe quatuorlineata* (Lacépède, 1789) by a common buzzard *Buteo buteo* (Linnaeus, 1758). *Acta Herpetologica* 5(1): 103–106. https://doi.org/10.13128/ACTA_HERPETOL-8538.

Bjelica, V., Anđelković, M., Lakušić, M., Maričić, M., Arsovski, D., Tomović, L. & Golubović, A. (2023). A dicey situation: capture behaviours in free-ranging dice snakes. *Behavioral Ecology and Sociobiology* 77: 48. https://doi.org/10.1007/s00265-023-03323-9.

Böhme, W. & Ščerbak, N.N. (1993). *Elaphe quatuorlineata* (Lacépède, 1789). In *Handbuch der Reptilien und Amphibien Europas*, Vol. 3/I, Schlangen (Serpentes) I, 373–396 pp. Böhme, W. (Ed.). Wiesbaden: Aula-Verlag.

Bonnet, X., Aubret, F., Lourdais, O., Ladyman, M., Bradshaw, D. & Maumelat, S. (2005). Do 'quiet' places make animals placid? island vs. mainland tiger snakes. *Ethology* 111(6): 573–592. https://doi.org/10.1111/j.1439-0310.2005.01070.x.

Brodie III, E.D. & Brodie Jr, E.D. (2004). Venomous snake mimicry. In *The Venomous Reptiles of the Western Hemisphere*, 617–633 pp. Campbell, J.A. & Lamar, W.W. (Eds.). London: Comstock.

Caro, T. (2014). Antipredator deception in terrestrial vertebrates. *Current Zoology* 60(1): 16–25. https://doi.org/10.1093/czoolo/60.1.16.

Cattaneo, A. (1998). Gli anfibi ei rettili delle isole greche di Skyros, Skopelos e Alonissos (Sporadi settentrionali). *Atti della Società Italiana di Scienze Naturali* 139: 127–149.

Cattaneo, A. & Grano, M. (2012). The Aegean populations of *Elaphe quatuorlineata* (Lacépède, 1789): A morpho-ecological examination. In *Old World Ratsnakes. A collection of papers*. 269–288 pp. Schulz, K.-D. (Ed.). Berg: Bushmaster Publications.

De Solan, T., Renoult, J.P., Geniez, P., David, P. & Crochet, P.-A. (2020). Looking for mimicry in a snake assemblage using deep learning. *The American Naturalist* 196(1): 74–86. https://doi.org/10.1086/708763.

Dell'Aglio, D., Toma, T., Esquivel Muelbert, A., Gomes Sacco, A. & Tozetti, A. (2012). Head triangulation as anti-predatory mechanism in snakes. *Biota Neotropica* 12(3): 315–318. https://doi.org/10.1590/S1676-06032012000300031.

Frynta, D., Elmi, H.S.A., Janovcová, M., Rudolfová, V., Štolhoferová, I., Rexová, K., Král, D., Sommer, D., Berti, D.A., Landová, E. & Frýdlová, P. (2023). Are vipers prototypic fear-evoking snakes? A cross-cultural comparison of Somalis and Czechs. *Frontiers in Psychology* 14: 1233667. https://doi.org/10.3389/fpsyg.2023.1233667.

Guimarães, M. & Sawaya, R.J. (2011). Pretending to be venomous: is a snake's head shape a trustworthy signal to a predator? *Journal of Tropical Ecology* 27(4): 437–439. https://doi.org/10.1017/S0266467411000095.

Hayakawa, S., Kawai, N. & Masataka, N. (2011). The influence of color on snake detection in visual search in human children. *Scientific Reports* 1: 80. https://doi.org/10.1038/srep00080.

Huang, S., Ding, L., Burbrink, F.T., Yang, J., Huang, J., Ling, C. & Chen, X. (2012). A new species of the genus *Elaphe* (Squamata: Colubridae) from Zoige County, Sichuan, China. *Asian Herpetological Research* 3(1): 38–45. https://doi.org/10.3724/SP.J.1245.2012.00038.

Kabisch, K. (1974). Die Ringelnatter. Wittenberg: Ziemsen-Verlag. 240 pp.

Kornilios, P., Thanou, E., Lymberakis, P., Sindaco, R., Liuzzi, C. & Giokas, S. (2014). Mitochondrial phylogeography, intraspecific diversity and phenotypic convergence in the four-lined snake (Reptilia, Squamata). *Zoologica Scripta* 43(2): 149–160. https://doi.org/10.1111/zsc.12045.

Lenk, P., Joger, U. & Wink, M. (2001). Phylogenetic relationships among European ratsnakes of the genus *Elaphe* Fitzinger based on mitochondrial DNA sequence comparisons. *Amphibia*-Reptilia 22(3): 329–339. https://doi.org/10.1163/156853801317050124.

Means, D.B. (2010). Blocked-flight aggressive behavior in snakes. *Reptiles & Amphibians* 17(2): 76–78. https://doi.org/10.17161/randa.v17i2.16079.

Niskanen, M. & Mappes, J. (2005). Significance of the dorsal zigzag pattern of *Vipera latastei gaditana* against avian predators. *Journal of Animal Ecology* 74(6): 1091–1101. https://doi.org/10.1111/j.1365-2656.2005.01008.x.

Qi, S., Shi, J.-S., Ma, Y.-B., Gao, Y.-F., Bu, S.-H., Grismer, L.L., Li, P.-P. & Wang, Y.-Y. (2021). A sheep in wolf's clothing: *Elaphe xiphodonta* sp. nov. (Squamata, Colubridae) and its possible mimicry to *Protobothrops jerdonii*. *ZooKeys* 1048: 23–47. https://doi.org/10.3897/zookeys.1048.65650.

Ruxton, G.D., Sherratt, T.N. & Speed, M.P. (2004). Avoiding Attack: The Evolutionary Ecology of Crypsis, Warning Signals and Mimicry. Oxford: Oxford University

Press. 260 p. https://doi.org/10.1093/acprof:oso/9780198528609.001.0001.

Schulz, K.-D. (1996). A Monograph of the Colubrid Snakes of the Genus *Elaphe*, Fitzinger. Havlíčkův Brod: Koeltz Scientific Books. 439 pp.

Speybroeck, J., Beukema, W., Bok, B. & van der Vort, J. (2016). Field Guide to the Amphibians and Reptiles of Britain and Europe. London: Bloomsbury Publishing. 432 pp.

Thanou, E., Kornilios, P., Lymberakis, P. & Leaché, A.D. (2020). Genomic and mitochondrial evidence of ancient isolations and extreme introgression in the four-lined snake. *Current Zoology* 66(1): 99–111. https://doi.org/10.1093/cz/zoz018.

Tuniyev, B., Tuniyev, S., Kirschey, T. & Mebert, K. (2011). Notes on the dice snake (*Natrix tessellata*) from the Caucasian Isthmus. *Mertensiella* 18: 345–356.

Utiger, U., Helfenberger, N., Schätti, B., Schmidt, C., Ruf, M. & Ziswiler, V. (2002). Molecular systematics and phylogeny of old and new world ratsnakes, *Elaphe Auct*., and related genera (Reptilia, Squamata, Colubridae). *Russian Journal of Herpetology* 9(2): 105–124.

Valakos, E., Pafilis, P., Sotiropoulos, K., Lymberakis, P., Maragou, P. & Foufopoulos, J. (2008). The Amphibians and Reptiles of Greece. Frankfurt am Main: Edition Chimaira. 563 pp.

Valkonen, J.K., Mäkelä, A., Mappes, J. & López-Sepulcre, A. (2018). Evaluating the potential for evolutionary mismatch in Batesian mimics: A case study in the endangered smooth snake (*Coronella austriaca*). *Evolutionary Applications* 11(9): 1512–1517. https://doi.org/10.1111/eva.12679.

Valkonen, J.K., Nokelainen, O. & Mappes, J. (2011). Antipredatory function of head shape for vipers and their mimics. *PLoS ONE* 6(7): e22272. https://doi.org/10.1371/journal.pone.0022272.

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NATURAL HISTORY NOTE

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A case of hyphema in the common toad *Bufo bufo* from eastern England

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The common toad *Bufo bufo* is the most widespread and populous toad species in Britain (Sterry, 2005). On 23 March 2016, during a routine amphibian survey, a common toad with a blood red left eye (Fig. 1), due to hyphema, was observed at Regatta Court, Cambridge, England (52.214397, 0.145655). None of the other toads in the same population were found with any form of injury. It is not known what caused this hyphema but given a nearby busy road and cycle path, trauma seems likely, although a bacterial or parasitic infection can produce the same result.

This is possibly the first record of a wild common toad affected by hyphema. Nearly all records of hyphema in amphibians are from captive anurans suffering bacterial or parasitic infection. Hyphema induced by the bacteria *Aeromonas hydrophila* and *Citrobacter freundii* is known in captive oriental red-bellied toads *Bombina orientalis* (Brooks et al., 1983) and induced by nematode infection in captive Asian horned frogs *Megophrys montana* (Imai et al., 2009). It would be of interest to record cases of hyphema in wild toads to establish its frequency and possible causes.

Figure 1. An adult common toad *Bufo bufo* with hyphema of the left eye, observed in Cambridge, England (image slightly blurred)

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REFERENCES

Brooks, D.E., Jacobson, E.R., Wolf, E.D., Clubb, S. & Gaskin, J.M. (1983). Panophthalmitis and otitis interna in fire-bellied toads. *Journal of the American Veterinary Medical Association* 183: 1198–1201.

Imai, D.M., Nadler, S.A., Brenner, D., Donovan, T.A & Pessier, A.P. (2009). Rhabditid Nematode-associated ophthalmitis and meningoencephalomyelitis in captive Asian horned frogs (*Megophrys montana*). *Journal of Veterinary Diagnostic Investigation* 21: 568–573.

Sterry, P. (2005). Collins Complete Guide to British Animals. London: HarperCollins Publishers Ltd. 186 pp.

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NATURAL HISTORY NOTE

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Polyandry in the northern Western Ghats vine snake *Ahaetulla borealis*

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The Indian tree snake *Ahaetulla borealis* Mallik et al. 2020 occurs in the northern and central parts of the Western Ghats mountain range. Its geographic range extends from the Matheran plateau (18° 59'58.92" N, 73° 16'20.64" E) in the north to Devimane ghat (14° 31'9.84" N, 74° 34'20.28" E) in the south. The species is commonly found in low-to-mid altitude, moist deciduous and semi-evergreen forests (Mallik et al., 2020). Despite its common occurrence, the ecology of *A. borealis* is scarcely documented, and available notes are unlikely to be attributed to its current nomen. Kinnear (1912; as *Dryophis mycterizans*) revealed the ovoviviparous nature of this species and reported 15 and 18 young ones in two individuals obtained from the Thane and Bhandup regions of the Bombay state (in present-day Maharashtra). Most other members of the genus *Ahaetulla* have also been observed to be ovoviviparous (Mohapatra et al., 2017; Fischer, 1915; Feldman et al., 2015). The mating season and reproductive strategies of *Ahaetulla* spp. are not established, and we did not find any report describing their mating behaviours.

Herein, we report the breeding behaviour of *A. borealis* from The Niche-Malnad Farmstay, Sonda, Karnataka (14° 44'2.76" N, 74° 45'29.88" E). On 26 September 2023, around 06:30 h, we observed a pair of *A. borealis* on the branches of an Indian laurel (*Terminalia elliptica*). The pair rested on a branch 4 m above the ground. The observation site featured mixed vegetation with areca palms and banana plantations on one side and rural homes on the other. Forest fragments were present a few metres away. Later in the afternoon (~16:30 h), we inspected the tree and found roughly seven individuals of various sizes dispersed over different branches. Two individuals were seen moving quickly between branches as if chasing one another, but we observed no pushing or biting behaviour. On the following morning (27 September 2023, at 08:00 h), we witnessed copulation. The female was notably larger than the other individuals, presumably all males, which were scattered on the tree. The snakes had not changed their positions on the same afternoon (~16:00 h), and copulation was still underway. By the following day, 28 September 2023, the snakes had coiled up together, forming a breeding ball around the female, and copulation was taking place (Fig. 1; BHS video, 2024). This breeding ball had at least five individuals, including the female. Several tails were firmly entwined around the female's abdomen and tail. Copulation did not occur at night since all individuals, except for the female, had scattered to distant branches on the same tree. We observed this breeding ball over the next two days. For the next 12 days, the snakes remained on the same tree, with no change in behaviour where the female stayed on the lower branch throughout and males moved to adjacent branches late evening and remained there until morning. On 13 October 2023, four individuals abandoned the site, leaving two males and one female. On 14 October 2023, all snakes had abandoned the site.

Figure 1. Several *Ahaetulla borealis* were seen on a branch of Indian Laurel four metres from the ground

This is the first report of a polyandrous breeding ball in the tree snake genus *Ahaetulla*. The male combat depicted here differed from prior descriptions of other species (Senter et al., 2014). The several males dangling on various tree branches moved using the body bridges other snakes built. However, their activity did not resemble 'body bridging' (as described in Greene & Mason, 2000), in the sense that neither pinning down nor chin rubbing took place. However, the behaviour of satellite males engaging in rapid chases on the tree was consistently observed across multiple days and appeared purposeful.

The formation of a mating ball seemed surprising for tree-dwelling species of snakes, given the constraints arboreality puts on free movement. A breeding ball has also been recorded among the oviparous tree snake *Dendrelaphis tristis* (Visvanathan et al., 2022), a close relative of the genus *Ahaetulla*. More observational studies are needed to disentangle the variety of ways in which tree-dwelling snake species reproduce. The high diversity in snake breeding behaviours implies the presence of a strong sexual selection in this lineage. Senter et al. (2014) found that the majority of courting and male-male combat behaviours are species-specific and phylogenetically unpredictable. This diversity in snake breeding behaviours should be examined in conjunction with the microhabitat preferences, activity times, and other ecological correlates that may be driving variations in breeding behaviours.

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REFERENCES

BHS video (2024). Mating ball of the northern Western Ghats vine snake *Ahaetulla borealis*. Recorded by Sulagno Mukherjee. https://youtube.com/shorts/A7198qP0Ur8.

Feldman, A., Bauer, A.M., Castro-Herrera, F., Chirio, L., Das, I., Doan, T.M., ... & Meiri, S. (2015). The geography of snake reproductive mode: a global analysis of the evolution of snake viviparity. *Global Ecology and Biogeography* 24(12): 1433−1442.

Fischer, C.E.C. (1915). *Dryophis dispar*. *Journal of the Bombay Natural History Society* 24: 194.

Greene, M.J. & Mason, R.T. (2000). Courtship, mating, and male combat of the brown tree snake, *Boiga irregularis*. *Herpetologica* 166: 175.

Kinnear, N.B. (1912). Notes on the size and breeding of the common green whipsnake (*Dryophis mycterizans*). *Journal of the Bombay Natural History Society* 21(3−5): 1336.

Mallik, A.K., Srikanthan, A.N., Pal, S.P., D'souza, P.M., Shanker, K. & Ganesh, S.R. (2020). Disentangling vines: a study of morphological crypsis and genetic divergence in vine snakes (Squamata: Colubridae: *Ahaetulla*) with the description of five new species from Peninsular India. *Zootaxa* 4874(1), 1−62.

Mohapatra, P.P., Dutta, S.K., Kar, N.B., Das, A., Murthy, B.H. C.K. & Deepak, V. (2017). *Ahaetulla nasuta anomala* (Annandale, 1906)(Squamata: Colubridae), resurrected as a valid species with marked sexual dichromatism. *Zootaxa* 4263(2): 318−332.

Senter, P., Harris, S.M. & Kent, D.L. (2014). Phylogeny of courtship and male-male combat behavior in snakes. *PloS ONE* 9(9): e107528.

Visvanathan, A., Anne, S., Kolli, A.K. & Vangari, S.M. (2022). Snakes of Telangana: An annotated checklist with new locality records and notes on natural history. *Reptiles & Amphibians* 29(1): 279−285.

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NATURAL HISTORY NOTE

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Barnacle infestation of two sea snakes *Hydrophis schistosus* and *Hydrophis curtus* in the Bay of Bengal

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Barnacles (Crustacea, Isopoda, Cymothoidae) are well known as marine ectoparasites and epibionts; their hosts/substrates included a wide range of animal species including sea snakes (Jeffries & Voris, 1979; Saravanakumar et al., 2012). Barnacles have a cement gland that secretes a protein matrix for underwater adherence, a necessary component for long-term attachment. In this study, we report barnacle infestation of two sea snake species *Hydrophis schistosus* and *Hydrophis curtus* in the northern Bay of Bengal. The known distribution of these sea snakes includes the Indian Ocean, Australia's northern coast and the South China Sea (Voris, 1972; Voris et al., 1978). Both species are acknowledged as being the most abundant sea snakes along India's coast (Daniel, 2002) although, to date, barnacles have only been reported once from Indian sea snakes (Saravanakumar et al., 2012).

Sea snakes were collected from the East Medinipur coast in West Bengal, India (21° 41'45.14" N, 87° 45'05.76" E) from November 2021 to February 2022. Fishermen occasionally catch sea snakes while operating trawlers and take them to landing areas where we investigate the dead snakes for traces of external parasites. The snakes were identified by reference to Smith (1926) and Rasmussen (1993). To enable a thorough examination of the barnacles these were collected from the snakes and stored in 70% ethanol. Barnacles were identified by their morphology, using a variety of sources (Bovallius, 1887; Bowman & Tareen, 1983; Bleeker, 1857; Bruce, 1990; Schioedte & Meinert, 1881; 1884) and by mitochondrial analysis. The mitochondrial DNA was isolated from the samples using the salt extraction method (Aljanabi & Martinez, 1997). The COI mitochondrial gene was amplified via PCR using both general and degenerate primers as follows: CrustF1- TTT TCT ACA AAT CAT AAA GAC ATT GG (Costa et al., 2007) and dgHCO- TAAACTTCAGGGTGACCAAARAAYCA (Meyer, 2003). The PCR reaction had a total volume of 21 µL and contained 2 x AmpliWin PCR mix, 10 pmol/µL of forward and reverse primers and 1 µL of template DNA. Reactions were run for 35 cycles with the following parameters: 30s at 94 °C; 40 cycles of 30s at 94 °C, 90 s at 51 °C, 60 s at 72 °C; followed by a final extension of 5 min at 72 °C. The PCR products were sequenced commercially at Barcode Biosciences, Bangalore, India.

Figure 1. An acorn barnacle *Amphibalanus amphitrite* on the cloaca of the sea snake *Hydrophis schistosus*

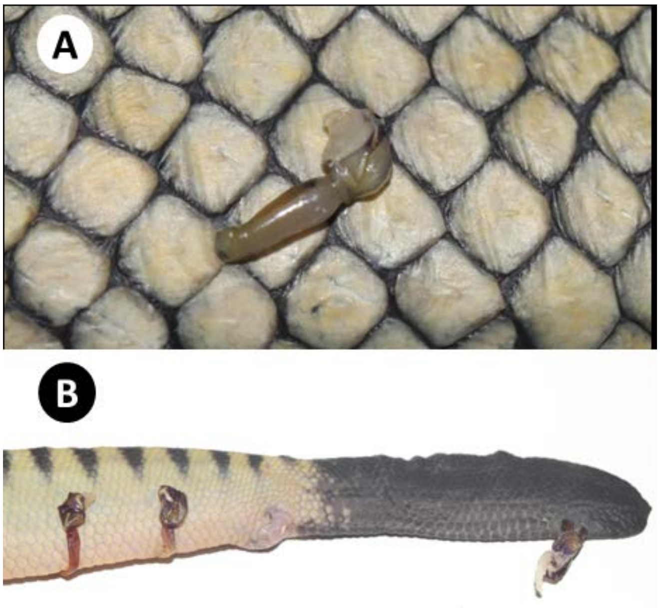

Figure 2. Small goose barnacles *Octolasmis warwickii* on sea snakes - **A.** *Hydrophis schistosus*, **B.** *Hydrophis curtus*

Figure 3. Algal growth on the skin of the sea snake *Hydrophis schistosus*

A total of 40 *H. schistosus* were examined of which 14 specimens had barnacles, and of the 26 *H. curtus* specimens 4 had barnacles. We identified two species of barnacle, the acorn barnacle *Amphibalanus amphitrite* (Fig. 1) and the small goose *Octolasmis warwickii* (Fig. 2); this is the first report of *O. warwickii* from the West Bengal coast. The identification of *O. warwickii* was confirmed for the analysis of mitochondrial DNA and sequences have been submitted to Genbank (Accession numbers PP002271 and PP349831). For *A. amphitrite*, PCR amplification did not work despite multiple attempts. So, specimens were identified only by their morphology.

Two specimens of *H. schistosus* were infested by both *A. amphitrite* and *O. warwickii*, for the rest, the barnacle infestation was restricted to a single species. In one *H. schistosus* specimen, a maximum of eight barnacles were found, of which four were *A. amphitrite* and four were *O. warwickii*. Barnacles were observed in the head to neck region (4%), midbody region (44%) and cloaca to tail region (52%). The barnacle attachment rate was higher in female sea snakes (67%) than male sea snakes (33%). Algal growth was also observed in one *H. schistosus* specimen (Fig. 3).

It is believed that certain *Octolasmis* spp may be obligate epibionts/ecoparasites on sea snakes (Jeffries & Voris, 1979). Long-term studies are needed to fully assess all the ecological variables that affect the relationship between sea snakes and barnacles.

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REFERENCES

Aljanabi, S.M. & Martinez, I. (1997). Universal and rapid salt-extraction of high quality genomic DNA for PCR-based techniques. *Nucleic acids research* 25(22): 4692–4693.

Bleeker, P. (1857). Recherches sur les Crustace´s de l’Inde Archipe´lagique. II. Sur les Isopodes Cymothoadiens de l’ Archipel Indien. *Acta Societatis Regiae Scientiarum Indo-Neerlandicae* 2: 20–40.

Bovallius, C. (1887). New or imperfectly known Isopoda. Part III. - Bihang till Kongelige Svenska Vetenskapsakademiens. *Handlingar* 18(4): 1–21.

Bowman, T.E. & Tareen, I.U. (1983). Cymothoidae from fishes of Kuwait (Arabian Gulf) (Crustacea, Isopoda). *Smithsonian Contributions to Zoology* 382: 1–30.

Bruce, N.L. (1990). The genera Catoessa, Elthusa, Enispa, Ichthyoxenus, Idusa, Livoneca and Norileca n. gen. (Isopoda: Cymothoidae), crustacean parasites of marine fishes, with descriptions of Eastern Australian species. *Records of the Australian Museum* 42: 247–300.

Daniel, J.C. (2002). The Book of Indian Reptiles and Amphibians. Bombay Natural History Society and Oxford University Press, Mumbai. 238 pp.

Jeffries, W.B. & Voris, H.K. (1979). Observations on the relationship between *Octolasmis grayii* (Darwin 1851) (Cirripedia, Thoracica) and certain marine snakes (Hydrophiidae). *Crustaceana* 37: 123–132.

Rasmussen, A.R. (1993). The status of the Persian Gulf sea snakes *Hydrophis lapemoides* (Gray, 1849) (Serpentes, Hydrophiidae). Bulletin of the Natural History Museum. *Zoology series* 59(2): 97–105.

Saravanakumar, A., Balasubramanian, T., Raja, K. & Trilles, J.P. (2012). A massive infestation of sea snakes by cymothoid isopods. *Parasitology Research* 110(6): 2529–2531.

Smith, M.A. (1926). Monograph of the Sea-Snakes (Hydrophiidae). British Museum (Natural History), London. 164 pp.

Schioedte, J.C. & Meinert, F. (1881). Symbolae ad monographiam cymothoarum crustaceorum isopodum familiae. II. *Anilocridae Naturhistorisk Tidsskrift* Ser III 13: 1–166.

Schioedte, J.C. & Meinert, F. (1884). Symbolae ad monographiam Cymothoarum Crustaceorum Isopodum Familiae. IV. Cymothoidae. TRIB. II. Cymothoinae. TRIB. III. *Livonecinae Naturhistorisk Tidsskrift* Ser. III XIV: 221–454, pls VI–XVIII (Cym. XXIV–XXXVI).

Voris, H.K. (1972). The role of sea snakes (Hydrophiidae) in the trophic structure of coastal ocean communities. *Journal of the Marine Biological Association of India* 14 (2): 429–432.

Voris, H.K., Voris, H.H, & Lim, L.B. (1978). The food and feeding behaviour of a marine snake, *Enhydrina schistosa* (Hydrophiidae). *Copeia* 1978(1): 134–146.

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NATURAL HISTORY NOTE

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Hissing – first description of this defensive behaviour by the reticulate wormsnake *Amerotyphlops reticulatus*

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The Scolecophidia is a group of basal snakes popularly known as blindsnakes, threadsnakes or wormsnakes (Vidal et al., 2010). Among the Scolecophidia, several defence strategies are known that include - escaping, spiking with the terminal spine, erratic movements, body contortion and thrashing, cloacal discharge, secretion of foul substances, knotting, thanatosis and even colour change - but to date these snakes have not been reported to hiss (Visser, 1966; Gehlbach et al., 1968; Watkins II et al., 1969; Gehlbach, 1970; Webb & Shine, 1993; Martins, 1996; Ernst & Ernst, 2003; Martins et al., 2018; Acuña-Vargas et al., 2021). In contrast, many species of 'higher' snake (Alethinophidia) may emit a hissing sound upon inhalation/exhalation, caused by air vibrations in the windpipe (Young, 2003; Muscat & Rotenberg, 2016; Fernandes et al., 2023). Hissing may be effective in deterring predators that rely on hearing, such as birds and mammals, as it causes alertness and fear in the predator, often dissuading them from capturing the prey (Fernandes et al., 2023).

Amerotyphlops reticulatus (Linnaeus, 1758) belongs to the family Typhlopidae, and is one of South America's largest wormsnakes, with a maximum recorded length of 522 mm (Dixon & Hendricks, 1979). It is nocturnal and preys upon the larvae of social insects (Beebe, 1946; Cunha & Nascimento, 1978; Aponte-Gutiérrez, 2021). This species is widespread in northern South America, especially in the Amazon (Nogueira et al., 2019).

On 14 May 2019, during a field trip in a Cerrado Gallery forest in Campo Julio Municipality, Mato Grosso, Brazil (13° 20'52.08" S, 59° 23'39.00" W), an adult *A. reticulatus* (Fig. 1) was discovered lying motionless amidst the forest floor litter. The heavy rainfall of the preceding day had saturated the ground, likely prompting the snake to venture from its burrow. The snake was briefly captured for photographic documentation. Upon handling, the snake opened its mouth and emitted a short hissing sound (BHS video, 2024). This behaviour recurred whenever the snake was touched or gently squeezed, with the sounds being brief and ceasing immediately thereafter. Following photography, the snake was released.

This hissing behaviour, described for the first time in a scolecophidian snake, is a significant addition to the defensive strategies of the group and to the known defensive repertoire of *A. reticulatus*. Further research is needed to understand its prevalence and evolutionary significance since it may have evolved independently or be a common ancestral feature shared with alethinophidian snakes.

Figure 1. The individual of *Amerotyphlops reticulatus* in a defensive posture in Campo Julio Municipality, Mato Grosso, Brazil

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REFERENCES

Acuña-Vargas, J.C. & Camargo-Gonzales, L.T. (2021). *Amerotyphlops reticulatus* (American reticulate blindsnake). Defensive behavior and traditional use. *Herpetological Review* 52(1): 146.

Aponte-Gutiérrez, A.F. (2021). Reticulate worm snake (*Amerotyphlops reticulatus*). Available online at: https://www.reptilesofecuador.com/amerotyphlops_reticulatus.html. Accessed on 10 March 2024.

Beebe, W. (1946). Field notes on the snakes of Kartabo, British Guiana, and Caripito, Venezuela. *Zoologica* 31: 11–52.

BHS video (2024). Hissing behaviour of the worm snake

Amerotyphlops reticulatus. https://youtu.be/j1Q9Swk9gO8.

Cunha, O.R. & Nascimento, F.P. (1978). Ofídios da Amazônia. X. As cobras da região leste do Pará. *Papéis Avulsos Museu Paraense Emílio Goeldi* 31: 1–218.

Dixon, J.R. & Hendricks, F.S. (1979). The wormsnakes (Family Typhlopidae) of the Neotropics, exclusive of the Antilles. *Zoologische Verhandelingen* 173: 1–39.

Ernst, C.H. & Ernst, E.M. (2003). Snakes of the United States and Canada. Washington DC: Smithsonian Books. 680 p.

Fernandes, I.Y., Koch, E.D. & Monico, A.T. (2023). First record of a snake call in South America: the unusual sound of an ornate snail-eater *Dipsas catesbyi*. *Acta Amazonica* 53: 243–245.

Gehlbach, F.R. (1970). Death-feigning and erratic behavior in Leptotyphlopid, Colubrid and Elapid Snakes. *Herpetologica* 26: 24–34.

Gehlbach, F.R., Watkins II, J. & Reno, H.W. (1968). Defensive behavior elicited by ant attacks. *Bioscience* 18: 784–785.

Martins, A., Baptista, G.M., Maciel, D.B. & Gonzalez, R.C. (2018). A new defensive behaviour for threadsnakes and the defensive repertoire of *Trilepida jani* (Pinto & Fernandes, 2012) (Epictinae: Leptotyphlopidae). *Herpetology Notes* 11: 839–841.

Martins, M. (1996). Defensive tactics in lizards and snakes: the potential contribution of the Neotropical fauna. *Anais de Etologia* 14: 185–199.

Muscat, E. & Rotenberg, E.L. (2016). *Spilotes pullatus* (Caninana) Defensive behaviour. *Herpetological Review* 47(2): 316

Nogueira, C.C., Argôlo, A.J.S., Arzamendia, V., Azevedo, J.A., Barbo, F.E., Bérnils, R.S. et al. (2019). Atlas of Brazilian Snakes: Verified point-locality maps to mitigate the Wallacean shortfall in a megadiverse snake fauna. *South American Journal of Herpetology* 14(1): 1–274.

Vidal, N., Marin, J., Morini, M., Donnellan, S., Branch, W.R., Thomas, R., Vences, M., Wynn, A., Cruaud, C. & Hedges, B. (2010). Blindsnake evolutionary tree reveals long history on Gondwana. *Biology Letters* 6: 558–561.

Visser, J. (1966). Colour change in *Leptotyphlops scutifrons* (Peters) and notes on its defensive behavior. *Zoologica Africana* 2: 123–125.

Watkins II, J.F., Gehlbach, F.R. & Kroll, J.C. (1969). Attractant-repellent secretions of blind snakes (*Leptotyphlops dulcis*) and their army ant prey (*Neivamyrmex nigrescens*). *Ecology* 50: 1098–1102.

Webb, J.K. & Shine, R. (1993). Prey-size selection, gape limitation and predator vulnerability in Australian blind snakes (Typhlopidae). *Animal Behavior* 45: 1117–1126.

Young, B.A. (2003). Snake bioacoustics: toward a richer understanding of the behavioral ecology of snakes. *The Quarterly Review of Biology* 78(3): 303–325.

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A tail where a limb should be: malformation of an adult Italian wall lizard *Podarcis siculus*

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In reptiles, successful regeneration is usually restricted to the replacement of the tail, mainly in lacertid lizards that perform tail autotomy (self-amputation) as a defensive strategy (Clause & Capaldi, 2006; Alibardi, 2010). Unlike the tail, limb loss in a terrestrial environment is generally fatal and it appears that there has been no selection for limb regeneration during lizard evolution (Alibardi, 2021). In lacertid lizards, morphological anomalies pertain mostly to bifurcated (Kumbar et al., 2011; Tamar et al., 2013) or even trifurcated regenerated tails (Pheasey et al., 2014; Koleska & Jablonski, 2015). Here we report a case of hind limb malformation in the Italian wall lizard *Podarcis siculus*. This species is a small-bodied (snout-vent length up to 90 mm) lacertid lizard characterised by high morphological and chromatic variability (Corti et al., 2011). Its native distribution spreads through the Italian peninsula, Sicily and the north Adriatic coast. However, this species is known for its high colonising potential, and besides Europe *P. siculus* has established several thriving populations on three continents: Africa, Asia and North America (Corti et al., 2011).

The specimen with the morphological malformation was identified in the herpetological collection of one of the authors of this note (G. Aloise, collection number 051). It is an adult female with head-body length: 57 mm, and tail autotomised, weighing 32 g. It was collected on 25 October 2003 in Contrada Prato, Palmi, Province of Reggio Calabria, southern Italy: 38° 22´22'' N, 15° 53´26´´E; 102 m a.s.l.), during a herpetological survey. Its general appearance is typical for the species, but the right hind-limb has a strange tail-like extremity (Fig. 1A). At the end of the upper hind thigh, the lower hind limb and hindfoot are replaced by a short protruding structure 8.87 mm length. The tip of this structure is similar to that of a tail (Fig. 1B), and no toes are present. The characteristic segments of the tail are well shaped. A radiographic image of the specimen revealed that the femur has an incomplete diaphysis, and the most distal bony portions of the limb are absent, so that the tail-like structure is not supported by bony parts (Fig. 1C). Such limb malformations are rather sporadic and are regarded as having environmental or genetic origin (Khan et al., 2005; Alibardi,

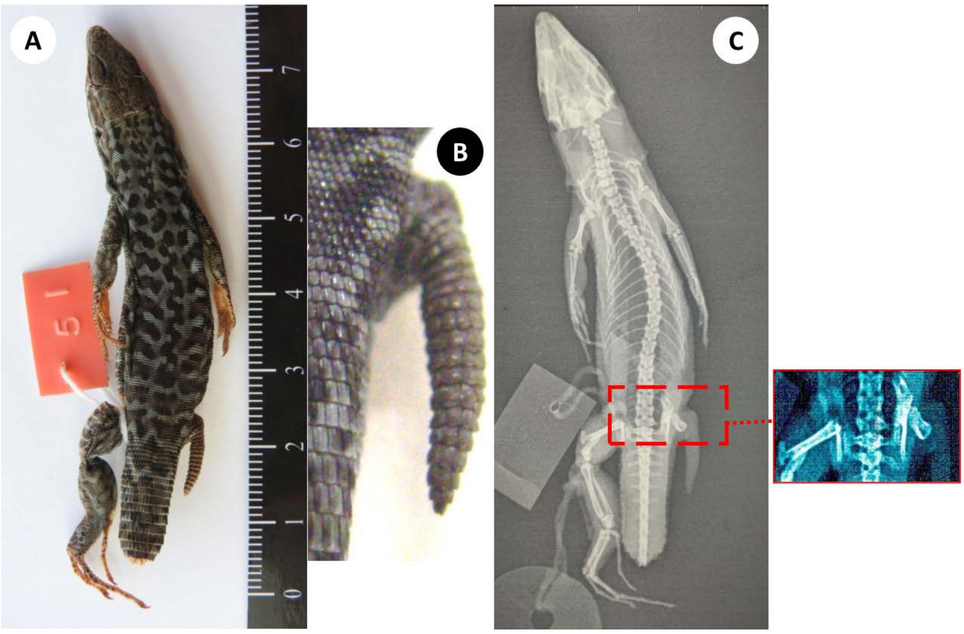

Figure 1. Female *Podarcis siculus* from Contrada Prato, Palmi, Province of Reggio Calabria, southern Italy, in which a tail-like structure has regenerated in the place of the right-hand hind-limb - **A.** Dorsal view, **B.** Close-up view of the tail-like structure, **C.** Radiograph revealing that the tail-like structure which regenerated in place of the right-hand hind-limb is not supported by bony parts

2017; Cortada et al., 2017). Hind limb malformations can occur when an initial blastema cone grows and mesenchymal cells rapidly differentiate into fibrocytes, giving place to short outgrowths or, in rare cases like this, to a tail-like appendage. A few similar cases have been reported for other lacertid lizard species: *Lacerta agilis* (Weiss, 1930; Olsson et al., 1996), *Podarcis erhardii* (Gkourtsouli-Antoniadou et al., 2017), *Podarcis lilfordi* (Cortada et al., 2017), *Podarcis muralis* (Guyénot & Matthey, 1928), *Takydromus takydromoides* (Okada, 1945), *Zootoca vivipara* (Kolenda et al., 2017) and have even been induced by experimental amputation in *P. muralis* (Guyénot & Matthey, 1928). To our knowledge the case we report here is the first documented record for *P. siculus*.

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REFERENCES

Alibardi, L. (2010). Morphological and cellular aspects of tail and limb regeneration in lizards: a model system with implications for tissue regeneration in mammals. *Advances in Anatomy, Embryology, and Cell Biology* 207: 1–109.

Alibardi, L. (2017). Review: Biological and molecular differences between tail regeneration and limb scarring in lizard, an inspiring model addressing limb regeneration in amniotes. *Journal of Experimental Zoology Part B* 328: 493–514.

Alibardi, L. (2021). Review: Limb regeneration in lizards under natural and experimental conditions with considerations on the induction of appendages regeneration in amniotes. *Annals of Anatomy - Anatomischer Anzeiger.* https://doi.org/10.1016/j.aanat.2021.151844.

Clause, A.R. & Capaldi, E.A. (2006). Caudal autotomy and regeneration in lizards. *Journal of Experimental Zoology Part A, Comparative Experimental Biology* 305: 965–973.

Cortada, À., Kaliontzopoulou, A., Mendes, J. & Carretero, M.A. (2017). A case of limb regeneration in a wild adult *Podarcis lilfordi* lizard. *Turkish Journal of Zoology* 41: 1069–1071.

Corti, C., Capula, M., Luiselli, L., Razzetti, E. & Sindaco, R. (2011). *Fauna d'Italia. Vol. XLV, Reptilia*. Edizioni Calderini de Il Sole 24 ORE S.p.A., Bologna. 870 pp.

Gkourtsouli-Antoniadou, I., Deimezis-Tsikoutas, A., Vassaki. K., Vezyrakis, A. & Pafilis, P. (2017). A tail where it shouldn't be: a morphological anomaly in *Podarcis erhardii*. *Herpetology Notes* 10: 233–234.

Guyénot, E. & Matthey, R. (1928). Les processus régénératifs dans la patte posterieure du lezard. *Wilhelm Roux' Archiv für Entwicklungsmechanik der Organismen* 113: 520–529.

Khan, Z.M.D. & Law, F.C.P. (2005). Adverse effects of pesticides and related chemicals on enzyme and hormone systems of fish, amphibians and reptiles: a review. *Proceedings of the Pakistan Academy of Sciences* 42: 315–323.

Kolenda, K., Wieczorek, M., Najbar, A., Najbar, B. & Skawiński, T. (2017). Limb malformation and tail bifurcation in sand lizards (*Lacerta agilis*) and common lizards (*Zootoca vivipara*) from Poland. *Herpetology Notes* 10: 713–716.

Koleska, D. & Jablonski, D. (2015). Tail trifurcation recorded in *Algyroides nigropunctatus* (Duméril & Bibron, 1839). *Ecologica Montenegrina* 3: 26–28.

Kumbar, S.M., Ghadage, A.B. & Shendage, V.M. (2011). *Hemidactylus flaviviridis* (House Gecko). Bifurcation. *Herpetological Review* 42: 94.

Okada, Y.K. (1945). Tail-like regeneration of the hind limb in the lizard *Takydromus tachydromoides*. *Annotationes Zoologicae Japonenses* 23: 13–22.

Olsson, M., Gullberg, A. & Tegelström, H. (1996). Malformed offspring, sibling matings, and selection against inbreeding in the sand lizard (*Lacerta agilis*). *Journal of Evolutionary Biology* 9: 229–242.

Pheasey, H., Smith, P., Brouard, J.P. & Atkinson, K. (2014). *Vanzosaura rubricauda* (Red-tailed Vanzosaur). Bifurcation and trifurcation. *Herpetological Review* 45: 138–139.

Tamar, K., Maza, E. & Meiri, S. (2013). *Ophisops elegans* (snake-eyed lizard). Bifurcation. *Herpetological Review* 44: 146.

Weiss, P.A. (1930). Potenzpriifung am Regenerationsblastem II. DasVerhalten des Schwanz blastems nach Transplantation an die Stelle der Vorderextremität bei Eidechsen (Lacerta). *Wilhelm Roux' Archiv für Entwicklungsmechanik der Organismen* 122: 379–394.

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NATURAL HISTORY NOTE

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Mali screeching frog *Tomopterna milletihorsini* range extension to southern Algeria

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The Mali screeching frog *Tomopterna milletihorsini* (Angel, 1922), is the sole representative of the genus *Tomopterna* in north-western Africa, although the genus *Tomopterna* comprises 18 species of burrowing frogs that are distributed across a vast expanse of sub-Saharan Africa (Frost, 2024). *Tomopterna milletihorsini* inhabits southern and central Mauritania, south-western Mali (including Bamako) and Senegal (Padial et al., 2014) and possibly might extend further east into Niger and other Sahelian regions (Fig. 1). However, the continental distribution of this species is still poorly known (Le Berre, 1989; IUCN, 2017; Channing & Rödel, 2019). Dumont (1987) reported this species from the Ghat oases in south-western Libya, but without any confirmatory details or photographs the identification remains uncertain. Therefore *T. milletihorsini* is not currently included in the Libyan batrachofauna (Schleich et al., 1996; Ibrahim, 2013; Escoriza & Ben Hassine, 2019; Blackburn et al., 2022).

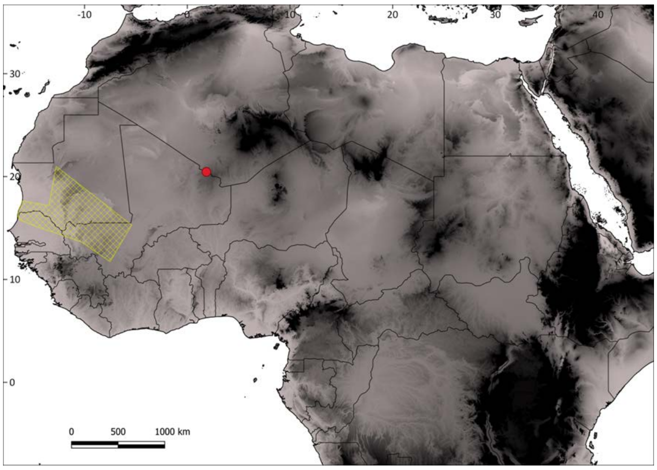

Figure 1. The distribution of *Tomopterna milletihorsini* in north-western Africa, yellow polygon, according to Escoriza & Ben Hassine (2019), and the newly discovered population (red dot)

Figure 2. Acacia woodland habitat of *Tomopterna milletihorsini* in Timiaouine, southern Algeria

In 2022, during a fauna survey in southern Algeria, several individuals that could belong to this species were found in the Timiaouine region close to the Mali border (20.45° N, 1.85° E, 584 m. a.s.l). The habitat was a typical Sahelian acacia savanna (Fig. 2). The small size (30 mm snout-urostyle), compact and robust build with short limbs and presence of a large, flange-like inner metatarsal tubercle on the feet all supported the assignment of these individuals to the genus *Tomopterna* (Escoriza & Ben Hassine, 2019) (Fig. 3). The short, vertical snout, absence of parotoids, tympanum not visible, vertically oval pupils with a small lower notch, and the presence of small tubercles scattered on the dorsum (in contrast to a densely rugous skin covered with spiny tubercles), all distinguished these individuals from other terrestrial Sahelian toads (*Sclerophrys xeros* and *Sclerophrys pentoni*). These Algerian individuals showed a uniform creamy brown dorsum with small, darker spots scattered across the back and limbs. Their overall colouration

Figure 3. Adult *Tomopterna milletihorsini* from Timiaouine, southern Algeria

was lighter when compared to *T. milletihorsini* individuals examined from Mauritania (Escoriza & Ben Hassine, 2019).

This new record considerably extends the northern range of this species distribution and also suggests that *T. milletihorsini* could be much more widespread in western Mali. However further studies will be necessary to confirm that these Algerian populations belong to the same species occurring in south-western Mali (terra typica of *T. milletihorsini*), Senegal and Mauritania.

REFERENCES

Blackburn, D., Nielsen, S.V. & Jdeidi, T. (2022). Atlas of the Frogs of Libya. *Herpetological Review* 53: 211–219.

Channing, A. & Rödel. M.O. (2019). Field Guide to the Frogs & Other Amphibians of Africa. Johannesburg: Struik Nature. 407 pp.

Dumont, H.J. (1987). Sahara. In *African Wetlands and Shallow Water Bodies*, 79–154 pp. Burgis, M.J. & Symoens, J.J. (Eds.). Paris: ORSTOM.

Escoriza, D. & Ben Hassine, J. (2019). Amphibians of North Africa. London: Elsevier Academic Press. 350 pp.

Frost, D. (2024). Amphibian Species of the World: an Online Reference. Version 6.2. Available at https://amphibiansoftheworld.amnh.org/. Accessed on 24 May 2024.

Ibrahim, A.A. (2013). Amphibians in Libya: a status report. *Basic Applied Herpetology* 27: 101–106.

IUCN Amphibian Specialist Group (2017). *Tomopterna milletihorsini*. The IUCN Red List of Threatened Species: e.T54375A18405602.

Le Berre, M. (1989). La faune du Sahara 1: Poissons, Amphibiens, Reptiles. Paris: Lechevalier and Chabaud, 332 pp.

Padial, J.M., Crochet, P.A., Geniez, P. & Brito, J.C. (2014). Amphibian conservation in Mauritania. *Basic Applied and Herpetology* 27: 11–22.

Schleich, H.H., Kästle, W. & Kabisch, K. (1996). Amphibians and Reptiles of North Africa. Kögnistein: Koeltz. 630 pp.

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The first record of the littoral skink *Emoia atrocostata* preying on a marine fish, the pearlyspot blenny *Praealticus margaritarius*

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The littoral skink *Emoia atrocostata* is widely distributed in the Indo-Australian Archipelago and Pacific islands, including the Miyako Islands Group of the Ryukyu Archipelago, Japan (Richmond et al., 2021). In a recent phylogenetic study, Richmond et al. (2021) recognised four genetically distinctive lineages within *E. atrocostata*, which were paraphyletic as a whole against a few closely related species. The population of the Miyako Islands belongs to the north-western Pacific lineage along with those in Taiwan, the Philippines and Yap Island. This skink mainly inhabits rocky shores or mangrove forests and is found in the intertidal zone during low tide (Alcala & Brown, 1967; Huang, 2011; Asato et al., in press). Knowledge regarding their diet is very limited, and only a few insects (Afrophoridae and Formicidae) and crabs were hitherto reported as stomach contents of the Taiwan population (Huang, 2011).

On 8 October 2022, during a field survey of the population status of *E. atrocostata* on the southern coast of Miyakojima Island (24° 43’27.06” N, 125° 21’30.60” E), we had an opportunity to obtain evidence of this skink predating a blenny. It was sunny and the air temperature was about 29 ˚C. The coastal area where we conducted the survey consisted of outcrops of bare limestone and a few small estuaries covered with coral gravel with many tidal pools at low tide. In this area, we regularly observe active *E. atrocostata* on limestone rocks and boulders in the upper tidal zone as well as those in intertidal zone at the low tide. At 10:30 h, we caught an individual *E. atrocostata* by hand while it was basking on a boulder in the intertidal zone of an estuary. At that time, the tide was ebbing and several tide pools had already appeared, and the distance from the skink to the nearest tidal pool was approximately 10 metres. Immediately after capture, the skink regurgitated a blenny into the observer’s hand. The skink was an adult male and the measurements were as follows: snout-vent length 75 mm, body weight 6.83 g, and maximum head width 10.0 mm, gape length (length from snout to mouth corner) 11.2 mm, gape width (distance between mouth corners on both sides) 9.2 mm (Fig. 1A). After measurements, the skink was released at the capture point. The prey blenny was fresh and intact without any injuries and was identified as a pearlyspot blenny *Praealticus margaritarius* based on the presence of a palm-like supraorbital tentacle, and small white spots scattered on the body (Nakabo, 2000). Later, this identification was confirmed by the DNA barcoding using a partial sequence of the mitochondrial 12S ribosomal RNA gene (168 bp). The prey was measured to have a total length of 57 mm (a standard body length of 51 mm), a maximum body width of 8.9 mm, and a body weight of 1.28 g (Fig. 1B). The skink regurgitated the blenny tail first. These circumstances suggest that the skink had caught the blenny when it was alive and had swallowed it head first.

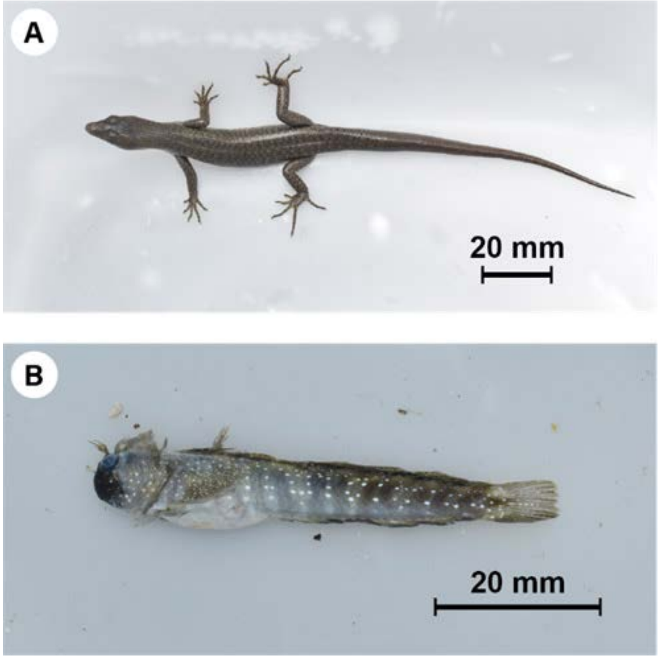

Figure 1. Predator skink and prey blenny - **A.** *Emoia atrocostata* (predator), and **B.** *Praealticus margaritarius* (prey)

The pearlyspot blenny is distributed in the north-west Pacific including Taiwan and Japan (Lee, 1980; Motomura, 2020) and lives mostly in the intertidal zone with where it displays amphibious behaviour (Ord & Cooke, 2016; Egan et al., 2021). Particularly, the blennies of the Ryukyu populations frequently foray out of the water to move between adjacent pools or into open water (Ord & Cooke, 2016). The species is quite common on the rocky coast of Miyakojima Island, and we found a number of blennies hopping on the wet surface of limestone outcrops. During low tide, there is a large overlap in the habitat use between

E. atrocostata and *P. margaritariusso* that they may easily encounter each other. Consequently, blennies are potentially not uncommon in the diet of *E. atrocostata*. Previously recorded cases of lizards as predators of fish are restricted to monitors (Varanidae) and the fish have generally been of freshwater species (e.g. Shine, 1986; Cota & Sommerlad, 2013; Karunarathna et al., 2017). Although several small-sized lizard species that inhabit coastal environments are known to prey upon marine invertebrates (e.g. Hazard et al., 1998; Janssen et al., 2015), predation of marine fish is quite rare. The pearlyspot blenny is a large-sized prey for *E. atrocostata* (over 18% of the skink's body weight in the present case) compared to other prey reported so far. If the predation on this species is common for *E. atrocostata* then it could account for a large proportion of the skink's nutritional intake.

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REFERENCES

Asato, H., Sasai, T., Yamamoto, T. & Toda, M. (in press). Population status of three endangered lizards on Shimojijima and Irabujima Islands, Ryukyu Archipelago, Japan. *Current Herpetology.*

Alcala, A.C. & Brown, W.C. (1967). Population ecology of the tropical scincoid lizard, *Emoia atrocostata*, in the Philippines. *Copeia* 3: 596–604.

Cota, M. & Sommerlad, R. (2013). Notes and observations on the fish prey of *Varanus salvator macromaculatus* (Reptilia: Squamata: Varanidae) in Thailand with a review of the fish prey of the *Varanus salvator* complex known to date. *Biawak* 7: 63–70.

Egan, J.P., Buser, T.J., Burns, M.D., Simons, A.M. & Hundt, P.J. (2021). Patterns of body shape diversity and evolution in intertidal and subtidal lineages of combtooth blennies (Blenniidae). *Integrative Organismal Biology* 3(1): obab004.

Hazard, L.C., Shoemaker, V.H. & Grismer, L.L. (1998). Salt gland secretion by an intertidal lizard, *Uta tumidarostra*. *Copeia* 1998(1): 231–234.

Huang, W.S. (2011). Ecology and reproductive patterns of the littoral skink *Emoia atrocostata* on an East Asian tropical rainforest island. *Zoological Studies* 50(4): 506–512.

Janssen, J., Towns, D.R., Duxbury, M. & Heitkönig, I.M. (2015). Surviving in a semi-marine habitat: dietary salt exposure and salt secretion of a New Zealand intertidal skink. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 189: 21–29.

Karunarathna, S., Surasinghe, T., Dissanayake, D., Botejue, M., Gabadage, D. & Madawale, M. (2017). Dietary habits and the predators of the Bengal monitor *Varanus bengalensis* in Sri Lanka. *Biawak* 11: 28–39.

Lee, S.C. (1980). Intertidal fishes of the rocky pools at Lanyu (Botel Tobago), Taiwan. *Bulletin of the Institute of Zoology, Academia Sinica* 19: 1–13.

Motomura, H. (2020). List of Japan's all fish species. Current standard Japanese and scientific names of all fish species recorded from Japanese waters. Kagoshima, Japan: The Kagoshima University Museum. 560 pp.

Nakabo, T. (2000). Fishes of Japan with pictorial keys to the species (2nd ed.), Tokyo, Japan: Tokai University Press. 1748 p.

Ord, T.J. & Cooke, G.M. (2016). Repeated evolution of amphibious behavior in fish and its implications for the colonization of novel environments. *Evolution* 70(8): 1747–1759.

Richmond, J.Q., Ota, H., Grismer, L.L. & Fisher, R.N. (2021). Influence of niche breadth and position on the historical biogeography of seafaring scincid lizards. *Biological Journal of the Linnean Society* 132(1): 74–92.

Shine, R. (1986). Food habits, habitats and reproductive biology of four sympatric species of varanid lizards in tropical Australia. *Herpetologica* 42(3): 346–360.

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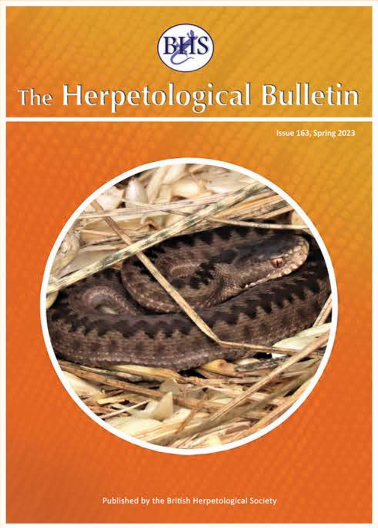
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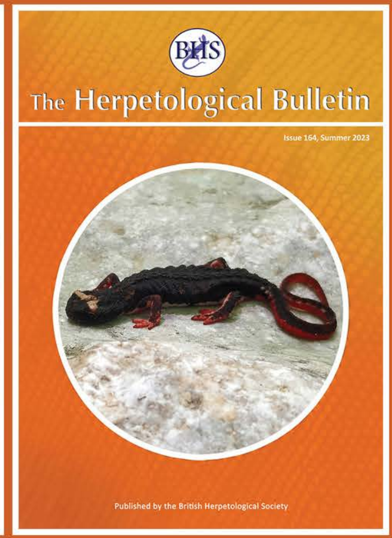
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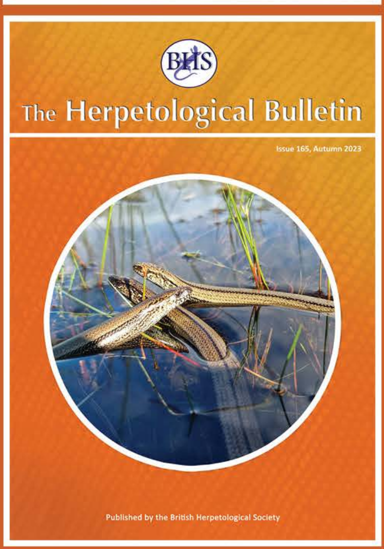
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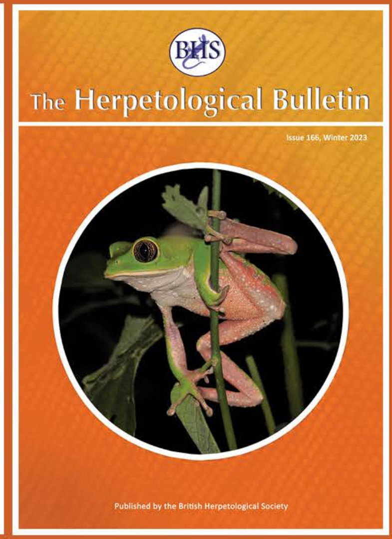
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